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The psammophilous grassland community *Corniculario aculeatae-Corynephoretum canescentis* in the Masurian Lake District (NE Poland)

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Abstract

This paper presents the results of a study on psammophilous grasslands, conducted during the years 1994–1997 and in 2008 in the Masurian Lake District (NE Poland). The study aimed at the determination of floristic composition, phytosociological diversity and habitat characteristics. Field work resulted in 511 phytosociological relevés. Soil samples were taken to determine pH, hydrolytic acidity, sum of basic cations, cation exchange capacity, content of $CaCO_3$ and total carbon. In 2008, the presence of communities dominated by grey-hair grass (*Corynephorus canescens*) in the previously established sites was checked. TWINSPAN was used for hierarchic classification of the association *Corniculario aculeatae-Corynephoretum canescentis* (syn. *Spergulo morisonii-Corynephoretum canescentis*). Accordingly, the association is divided into four subtypes (typical subtype, subtype with *Cladonia mitis*, subtype with *Thymus serpyllum* and subtype with *Festuca ovina*) with nine variants. Field observations showed that the communities analyzed have been under strong anthropogenic pressure, causing their degeneration and decrease in area. The most common human uses of psammophilous grassland communities are housing development, road construction, afforestation, sand extraction, wood storage and unauthorized dumping. In contrast to the above types of land use, seasonal use of grasslands for recreation purposes (as sunbathing spots or as sports fields) does not lead to their degeneration and may have a beneficial influence on their maintenance as a component of the local landscape.

Zusammenfassung: Sandtrockenrasen des *Corniculario aculeatae-Corynephoretum canescentis* im Gebiet der Masurischen Seenplatte (Nordost-Polen)

Die vorliegende Arbeit stellt Ergebnisse der in den Jahren 1994–1997 und 2008 durchgeführten Untersuchungen von Sandtrockenrasen der Masurischen Seeplatte vor. Es werden Artenzusammensetzung, syntaxonomische Differenzierung und Standorteigenschaften dieses Vegetationstyps auf der Basis von 511 pflanzensoziologischen Aufnahmen beschrieben. Ferner wurden pH-Wert, H-Wert, S-Wert, Kationenaustauschkapazität, Kalk- und Kohlenstoffgehalt der Böden bestimmt. 2008 wurden die aus der Erstuntersuchung bekannten Standorte von Sandtrockenrasen erneut überprüft. Eine hierarische Klassifikation der Vegetationsaufnahmen der Assoziation *Corniculario aculeatae-Corynephoretum canescentis* (syn. *Spergulo morisonii-Corynephoretum canescentis*) wurde mit dem Programm TWINSPAN durchgeführt. Demzufolge können innerhalb der Assoziation vier Ausbildungen (Tyische Ausbildung, Ausbildung mit *Cladonia mitis*, Ausbildung mit *Thymus serpyllum* und Ausbildung mit *Festuca ovina*) mit insgesamt neun Varianten unterschieden werden. Habitatuntersuchungen weisen auf starke Einflüsse des Menschen auf die Sandtrockenrasen hin. Zu den häufigsten Beeinträchtigungen gehören Zerstörung durch den Bau von Wohn- und Ferienhäusern, Straßenbau, Aufforstung, Sandabbau, Holzlagerung und wilde Müllkippen. Dagegen verursacht die saisonale Nutzung zu Erholungszwecken (Ufer, Fußballplätze) keine Degeneration dieser Habitate, sondern übt einen positiven Einfluss auf deren Erhaltung in der Landschaft aus.

Keywords: acidic sand, conservation, *Koelerio-Corynephoretea*, phytosociology, syntaxonomy, vulnerability.

1. Introduction

The Masurian Lake District comprises a wide range of habitats, which contributes to its species richness and to the diversity of its forest, peatland, grassland, aquatic and rush phytocenoses. Pioneer psammophilous grasslands on inland oligotrophic, acidic sand are widespread across all Poland, except submontane and montane regions. Inland sand dunes are often overgrown with partly damaged, sometimes semi-synanthropic vegetation (KORNAŚ 1977). Psammophilous grasslands are scarcely vegetated communities that develop on loose sand at the initial stage of secondary succession, following the degeneration or damage of primary vegetation. They can be found on fallow land, in logged and deforested areas, along forest margins and roadsides, in areas of former sandpits, etc. (W. MATUSZKIEWICZ 2001).

In Europe, the largest areas with the *Corniculario aculeatae-Corynephoretum canescentis* Steffen 1931 nom. invers. propos. occur in the basin of the Rhine, in the Northern German Plain and along the North Sea coast (TÜXEN & SCHWABE 1972, DIERSCHKE 1986, BIERMANN 1999, BOHN et al. 2000, DENGLER 2001). In Eastern Europe, the related association *Spergulo-Veronicetum dillenii* (Wójcik 1965) Warcholinska 1981 has been documented from Margionys in Lithuania (BALEVIČIENĖ et al. 2000). The easternmost occurrence of such communities has been reported by VICHEREK (1972) in the valley of the Dnepr, near Kiev (Ukraine). They were classified as *Veronico dillenii-Corynephoretum* Passarge 1960 with occurrences of *Spergula morisonii* and treated as a subcontinental vicariant of the subatlantic *Spergulo-Corynephoretum* (Tx. 1928) Passarge 1960. In Poland, such psammophilous vegetation has been described by numerous authors, who investigated habitats in such regions as the Warsaw Basin (JURASZEK 1928, KOBENDZA 1930), the West Pomeranian Lake District (LIBBERT 1933), Greater Poland (CELIŃSKI 1953, CZUBIŃSKI 1956, FILIPEK 1962, 1974, STANIEWSKA 1961), the Lublin region (FIJAŁKOWSKI 1964, 1969), the islands of Usedom and Wolin (PIOTROWSKA & CELIŃSKI 1965), the Chełmno-Dobrzyń Lake District (KĘPCZYŃSKI 1965, CEYNOWA 1968), the Sandomierz Upland and the Iłża Foreland (GŁAZEK 1968), the Trzebnica Embankment (GŁOWACKI 1975), the Poznań Lake District (WIKA 1975, CELIŃSKI & BALCERKIEWICZ 1973) and the Silesian-Cracovian Upland (BABCZYŃSKA 1978, CZYŻEWSKA 1986). A critical analysis of phytosociological data was performed in 1992 by CZYŻEWSKA, who concluded that in Poland communities dominated by grey-hair grass (*Corynephorus canescens*) belong to only one association, *Spergulo-Corynephoretum*, with two geographic vicariants, subatlantic and subcontinental. According to CZYŻEWSKA (1992), the *Spergulo-Corynephoretum* is the only association within the *Corynephorion canescentis* Klika 1931.

The name used in the title of this work – *Corniculario aculeatae-Corynephoretum canescentis* Steffen 1931 nom. invers. propos. – is the older name for the widely applied name "*Spergulo-Corynephoretum* (Tx. 1928) Libbert 1933" in the sense of CZYŻEWSKA (1992), JUŚKIEWICZ 1999, and MATUSZKIEWICZ (2001), which is a "phantom name" (see DENGLER et al. 2003) and according to the International Code of Phytosociological Nomenclature (WEBER et al. 2000) had to be replaced. The *Corniculario-Corynephoretum* was described from the Masurian Lake District by STEFFEN (1931) and the lectotype of this association chosen by DENGLER et al. (2003), namely STEFFEN (1931: p. 284, table 4, relevé number 6, location district Allenstein), is identical with the typical subtype of the *Corniculario-Corynephoretum* as delimited in this paper.

Pioneer grasslands on inland sand are a relatively rare landscape component in the Masurian Lake District, as this is an area dominated by more fertile, young glacial habitats, unfavorable to the development of psammophilous communities. The grasslands of the Masurian Lake District tend to be poorer in atlantic and subatlantic species.

Although they constitute a unique component of regional vegetation, psammophilous communities of the Masurian Lake District have been investigated only by a few authors, including PREUSS (1909, 1912), STEFFEN (1924, 1931, 1937), POLAKOWSKI (1963) and ENDLER & POLAKOWSKI (1978). My own studies in the years 1994–1997 (see also JUŚKIEWICZ 1999, JUŚKIEWICZ & ENDLER 1999) aimed at gathering a detailed phytosociological documentation regarding the association *Corniculario-Corynephoretum*. This provided a basis for distinguishing subassociations and variants with the use of a numerical analysis, followed by the determination of the floristic characteristics and ecological amplitude of the phytocenosis. The objective of the research carried out in May and June of 2008 was to assess the present condition of psammophilous grasslands in the Masurian Lake District.

2. Study area

According to the system of physical and geographical regionalization adopted in Poland (KONDRACKI 2001), the Masurian Lake District is a macroregion in Central Europe that belongs to the Province of West-Russian Lowlands and to the Subprovince of East Baltic Lake Districts. This macroregion is divided into seven mesoregions, of which two – the Olsztyn Lake District and the Masurian Plain – were included in my study (Fig. 1).

The limits of the major phases of the Vistulian glaciation (Leszno phase, Poznań phase, Pomeranian phase) meet in the Masurian Lake District area. During the Pomeranian phase, two arch-shaped depressions were created there by the glacier, which are today occupied by the Łyna River valley in the west and by a system of large lakes in the east. In the Pomeranian phase, the ice wall reached its furthest extent repeatedly, leaving sheets of dead ice, remains of which formed the lake basins. Vast sandurs, which mark the limits of the glacier's advance in the Leszno phase, occur in the southern part of the Masurian Lake District, in the Masurian Plain mesoregion (KONDRACKI 2001). The area is dominated by flat ground with a natural inclination of 0% to 6%. These plains surround small patches of morainal deposits characterized by more diversified relief. Sandur sediments are homogenous in respect to particle size, and can be classified as loose and slightly loamy sand (GOTKIEWICZ & SMOŁUCHA 1996). Arenosols and other light soils, including podsolic soils, formed from sandy material of the sandurs and are typical of the southern part of the macroregion (PIAŚCIK 1996).

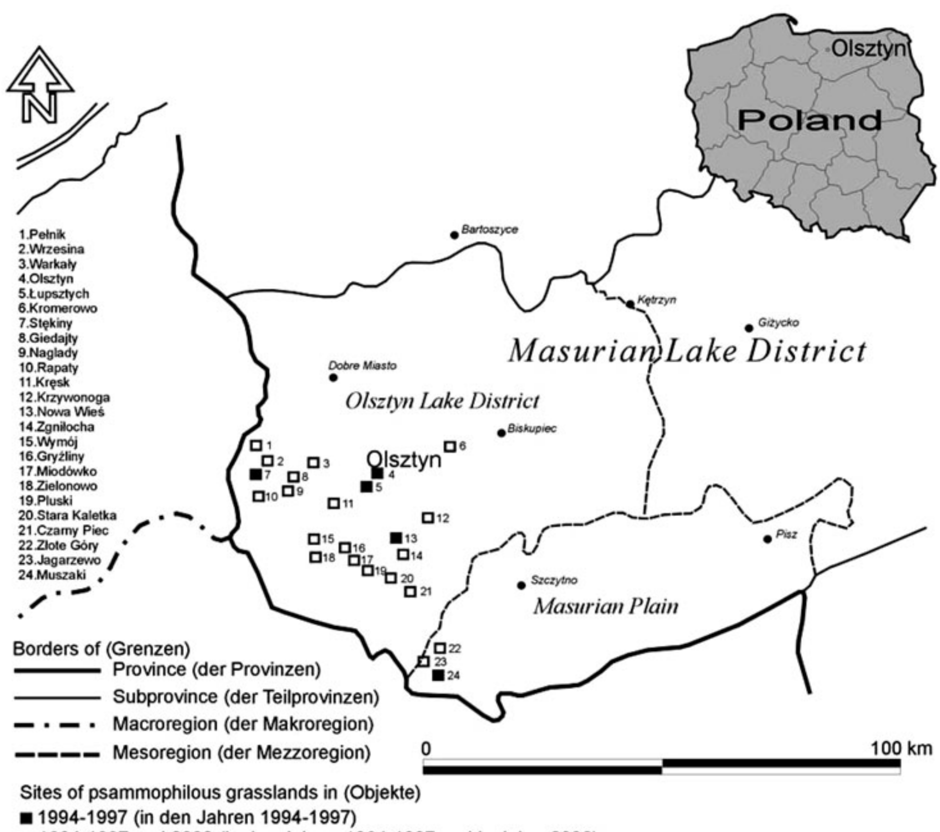

Fig. 1: Location of the *Corniculario-Corynephoretum* stands in the Masurian Lakeland that have been studied in the years 1994–2008.

Abb. 1: Lage der in den Jahren 1994–2008 untersuchten Bestände des *Corniculario-Corynephoretum* in der Masurischen Seenplatte.

The Masurian Lake District differs considerably from other regions of Poland with respect to climatic conditions, which is due to its geographical location, surface features, presence of numerous lakes and a high percentage of wooded area. Western and southwestern winds with velocities ranging from 2.5 to 4.0 m/s dominate in this macroregion (HUTOROWICZ et al. 1996). Mean annual temperature is 6.5 °C. The growing season lasts 210–217 days, whereas thermal winter on average lasts 103 days, with snow cover lasting for up to 96 days. The average annual precipitation is 573 mm (J. M. MATUSZKIEWICZ 2001).

3. Materials and methods

Comprehensive field investigations were conducted during the years 1994–1997 in the Masurian Lake District. Phytosociological relevés were sampled in 24 sites (Fig. 1) as the existing documented data suggested that until 1994 there had been very few semi-natural grassland sites remaining there. The plots were chosen for investigation based on their floristic uniformity, adequate area and suitable season of the year, and were placed subjectively. The floristic criterion used for placement of plots was the occurrence of *Corynephorus canescens* as well as *Spergula morisonii*, *Teesdalia nudicaulis* or *Veronica dillenii* as presumed character species of the association *Corniculario-Corynephoretum*. The BRAUN-BLANQUET (1964) method was used for the description of the vegetation. In general, the size of a relevé plot was 20–30 m^2. Data were gathered from May to September. The nomenclature of vascular plants, bryophytes and lichens follows MIREK et al. (1995), OCHYRA et al. (2003) and FAŁTYNOWICZ (2003), respectively.

Soil samples were taken from every plot to determine soil pH. Additionally, seven soil pits were dug at representative sites (where specifically defined phytosociological relevés were taken). Twenty-one soil samples were collected separately for different horizons. Laboratory analysis of soil samples was performed as described by DOBRZAŃSKI & UZIAK (1970) and DZIĘCIOŁOWSKI (1985) to determine pH (in H_2O and KCl), hydrolytic acidity (H), sum of basic cations (S), cation exchange capacity (CEC), the content of $CaCO_3$ and total carbon (C with Tiurin's method). Soil nomenclature follows TRZCIŃSKI (1989).

A total of 511 phytosociological relevés were entered into a database with the use of the database management system TURBOVEG (HENNEKENS 1995). TWINSPAN (HILL 1979) was used for classifying relevés and species. The nomenclature used to describe syntaxa derives from the system of plant associations elaborated by W. MATUSZKIEWICZ (2001), which is in general use in Poland. However, the names of the syntaxa have been updated according to the International Code of Phytosociological Nomenclature (WEBER et al. 2000). In this paper, syntaxa ranking as subassociations and variants have been distinguished according to the units derived from the TWINSPAN analysis. For the determination of differential species of these subunits, both percentage constancy (C) and mean cover (D) have been taken into account (see Table 1). Mean cover makes the differentiation possible in this system even when constancy is similar.

A site inspection was conducted in the spring of 2008 to verify the occurrence of the association as well as to evaluate its condition and potential transformation. Following the cartographic documents gathered during the 1994–1997 research, the route method (FALIŃSKI 2001) was applied to test the presence of grassland plots at the research sites.

4. Results and discussion

4.1. Floristic characteristics

The Masurian Lake District flora contains 1,269 species of vascular plants (JUTRZENKA-TRZEBIATOWSKI & DZIEDZIC 1989), which makes up about 56% of all taxa in Poland. Based on my research, the flora of psammophilous grasslands in the Masurian Lake District is composed of 216 taxa, around 17% of all plant species in this area. The vascular plant flora was dominated by hemicryptophytes (119 species), of which the following were most frequent and abundant: *Corynephorus canescens*, *Hieracium pilosella*, *Jasione motana, Scleranthus perennis, Rumex acetosella*, *Astragalus arenarius, Helichrysum arenarium, Achillea millefolium* agg. and *Hypochoeris radicata*. The group of therophytes (59 species) comprised the character species of the association *Corniculario-Corynephoretum*, such as *Spergula morisonii, Teesdalia nudicaulis* and *Veronica dillenii*. The subatlantic element was represented only by *Spergula morisonii*, *Teesdalia nudicaulis* and *Corynephorus canescens.* Protected species were not abundant in psammophilous grasslands in the Masurian Lake District: *Jovibarba sobolifera* ssp. *sobolifera* and *Primula veris* were extremely rare, while *Helichrysum arenarium* was relatively frequent (JUŚKIEWICZ & ENDLER 1999). The bryophyte and lichen floras included 12 and 26 species, respectively. The most frequent lichen species, determining the specific physiognomy of the phytocoenosis in the optimal succession stages, was *Cladonia arbuscula* ssp. *mitis*. The group of pioneer species was represented by *Cladonia fimbriata, C. subulata, C. chlorophaea, C. glauca* and *C. phyllophora*. The community was composed of only few but abundant bryophytes like *Ceratodon purpureus* and *Brachythecium albicans* in the initial stages, and by other dry grassland species, like *Polytrichum piliferum* and *Niphotrichum ericoides* (JUŚKIEWICZ-SWACZYNA & ENDLER 2006).

4.2. Phytosociological characteristics

The paper adheres to the syntaxonomic system suggested by CZYŻEWSKA (1992), based on KRAUSCH's system (1968), which until present has been a preferred system for classification of dry grasslands in Poland. However, some nomenclatural changes of syntaxon names were necessary according to ICPN (WEBER et al. 2000). To avoid nomenclatorical novelties, the invalid names of subassociations used in JUŚKIEWICZ (1999) are treated as informal subtypes here but with reference to the original names in brackets.

The association *Corniculario aculeatae-Corynephoretum canescentis* Steffen 1931 nom. invers. propos. (alliance *Corynephorion canescentis* Klika 1931, order *Corynephoretalia canescentis* Klika 1934, class *Koelerio-Corynephoretea* Klika in Klika & Novák 1941) is divided into four subtypes, typical subtype (*Spergulo-Corynephoretum typicum* Tx. ex Czyżewska 1992), subtype with *Cladonia arbuscula* ssp. *mitis*, (*S.-C. cladonietosum* Tx. (1928) 1937), subtype with *Thymus serpyllum* (*S.-C. thymetosum serpylli* Czyżewska 1992), which were identified in accordance with the syntaxonomic system proposed by CZYŻEWSKA (1992), and subtype with *Festuca ovina* (subassociation *S.-C. festucetosum ovinae* Krausch 1968), which was identified based on the occurrence of diagnostic species, according to KRAUSCH (1968).

The syntaxonomic identity assigned in this paper to grey-hair grass communities differs from the approach represented by many other European authors. In North-Eastern Germany, KRATZERT & DENGLER (1999) distinguished two subassociations within this association: *Corniculario-Corynephoretum typicum* and *cladonietosum* with the differential taxa *Cetraria aculeata*, *Cladonia furcata*, *C. arbuscula* ssp. *mitis*, *C. gracilis* and *Polytrichum piliferum*. In the Czech Republic the *Corniculario-Corynephoretum* comprises only two variants with *Spergula morisonii* and *Thymus serpyllum*, respectively (CHYTRÝ 2007). In turn, BOHN et al. (2000) described grey-hair grass communities in Emsland (Northern Germany) as *Spergulo-Corynephoretum*, and distinguished the subassociations *typicum* and *cladonietosum* with a typical variant and a variant with *Cladonia foliacea*. The study of KETNER-OOSTRA & SÝKORA (2004) from the inland drift-sand in central Netherlands presents the community *Spergulo-Corynephoretum typicum* (var. with *Ammophila arenaria*, var. with *Polytrichum piliferum*) and *Spergulo-Corynephoretum cladonietosum* (var. with *Polytrichum piliferum*, var. with *Campylopus introflexus*, var. with *Cladina* spp. and *Campylopus introflexus*, var. with *Cladina* spp. and *Cladonia strepsilis*, and var. with *Cladina* spp., *Festuca ovina* s.l., *Rumex acetosella*). According to W. MATUSZKIEWICZ (2001), the alliance *Corynephorion canescentis* is represented by several associations, namely *Spergulo-Corynephoretum*, *Corniculario-Cladonietum mitis* Krieger 1937, *Polytricho piliferi-Stereocauletum condensati* Zielińska 1967, and *Agrostietum coarctatae* Kobendza 1930 corr. Kratzert & Dengler 1999. CZYŻEWSKA (1992), on the other hand, postulates that the above alliance is represented only by the association *Spergulo-Corynephoretum*, and the associations determined by W. MATUSZKIEWICZ (2001) are in fact different forms of this association. This approach was also followed, for example, in a study describing plant communities from excavation areas and sun-exposed slopes on carbonate-free soils in the western part of the Drawsko Lake District (MŁYNKOWIAK & KUTYNA 2005). The above considerations on syntaxonomic systems suggest that the data presented herein need to be placed in a Europe-wide context and a uniform classification of dry grasslands should be adopted. However,

Table 1: Abridged synoptic table of the subunits of the *Corniculario-Corynephoretum* in Masurian Lake District. Species with low constancy and low mean cover (manly accompanying species) are not shown. C = constancy (%); D = mean cover (%).

Tab. 1: Gekürzte Stetigkeitstabelle der Untereinheiten des *Corniculario-Corynephoretum* in der Masurischen Seenplatte. Arten mit niedriger Stetigkeit und geringer mittlerer Deckung sind nicht wiedergegeben. C = Stetigkeit (%); D = mittlere Deckung (%).

Syntaxonomic unit	Typical subtype						Subtype with *Cladonia arbuscula* ssp. *mitis*				Subtype with *Thymus serpyllum*				Subtype with *Festuca ovina*			
	Variant with *Hypochoeris radicata*		Variant with *Artemisia campestris*		Typical variant		Typical variant		Variant with *Polytrichum piliferum*		Variant with *Cladonia arbuscula* subsp. *mitis*		Variant with *Festuca ovina*		Typical variant		Variant with *Agrostis capillaris*	
Number of relevés	88		108		54		67		49		29		33		65		18	
Mean cover of vegetation layers (%) shrub layer	0.5		2.5		7.7		2.8		4.1		0.1		1.3		0.9		0.2	
herb layer	87.6		84.1		82.4		79.8		86.1		96.2		93.6		91.8		77.8	
moss-lichen layer	27.2		41.5		36.9		73.5		57.7		64.7		40.5		42.4		35.6	
Mean plot size (m^2)	27.8		23.3		23.8		16.6		24.2		26.1		27.5		23.8		17.4	
Mean species richness (vascular plants)	20.5		18.3		14.6		14.7		19.1		25.6		25.1		24.7		19.8	
Mean species richness (bryophytes and lichens)	3.2		3.3		3.2		8.2		6.9		3.9		4.1		4.3		3.3	
Mean pH ($H_2$0)	5.5		6.8		5.2		5.5		5.6		6.4		5.2		5.6		5.6	
	D	**C**	D	**C**	D	**C**	D	**C**	D	**C**	D	**C**	D	**C**	D	**C**	D	**C**
Ch *Corniculario-Corynephoretum*																		
Spergula morisonii	5.80	**82**	3.53	**61**	3.32	**78**	1.47	**39**	2.54	**43**	4.24	**76**	5.55	**73**	5.63	**62**	0.02	**17**
Teesdalia nudicaulis	3.16	**65**	3.05	**52**	2.67	**61**	3.94	**67**	1.22	**69**	1.93	**72**	1.63	**61**	3.68	**60**	0.03	**28**
Veronica dillenii	1.44	**72**	1.57	**69**	0.30	**28**	1.22	**46**	0.86	**63**	3.41	**93**	1.74	**88**	1.99	**85**	0.91	**94**
D subtype with *Cladonia arbuscula* ssp. *mitis*																		
Cladonia arbuscula ssp. *mitis*	1.08	**33**	0.45	**12**	2.09	**24**	6.62	**76**	7.12	**92**	18.80	**86**	4.56	**48**	2.62	**20**	-	**-**
Cladonia cervicornis ssp. *verticillata*	7	**6**	0.05	**4**	-	**-**	3.44	**57**	4.41	**73**	-	**-**	0.01	**9**	-	**-**	-	**-**
D subtype with *Thymus serpyllum*																		
Thymus serpyllum	0.13	**2**	0.81	**7**	0.65	**6**	0.60	**4**	0.57	**12**	13.11	**90**	11.37	**67**	0.01	**9**	0.01	**11**
Brachythecium albicans	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	0.54	**31**	2.44	**36**	-	**-**	-	**-**
Cetraria aculeata	-	**-**	-	**-**	-	**-**	0.01	**4**	0.12	**18**	1.24	**52**	0.01	**3**	0.35	**9**	-	**-**

D subtype with *Festuca ovina*																								
Festuca ovina	0.52	**19**	1.20	**22**	0.20	**13**	0.18	**15**	1.69	**14**	4.16	**55**	26.31	**100**	7.29	**63**	8.08	**78**
Arenaria serpyllifolia	0.32	**15**	-	**-**	0.01	**4**	0.31	**12**	0.53	**33**	0.55	**38**	0.18	**30**	1.56	**45**	0.85	**44**
Ch *Corynephorion canescentis*																		
Cetraria muricata	-	**-**	-	**-**	0.42	**6**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**
Cladonia floerkeana	0.01	**1**	-	**-**	-	**-**	0.01	**2**	0.01	**2**	-	**-**	-	**-**	-	**-**	-	**-**
Cephaloziella starkei	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**	0.01	**3**	-	**-**	-	**-**
Cladonia macilenta	-	**-**	0.01	**1**	-	**-**	-	**-**	0.01	**6**	-	**-**	-	**-**	0.01	**2**	-	**-**
Cladonia uncialis	-	**-**	-	**-**	-	**-**	2.59	**20**	-	**-**	-	**-**	-	**-**	-	**-**	-	**-**
Ch *Corynephoretalia* and *Koelerio-Corynephoretea*																		
Corynephorus canescens	10.73	**82**	19.66	**94**	43.29	**100**	26.27	**97**	17.05	**100**	22.33	**83**	5.39	**67**	2.31	**69**	0.02	**17**
Hieracium pilosella	9.32	**88**	23.13	**94**	10.68	**93**	24.11	**90**	28.17	**98**	13.20	**86**	15.38	**100**	19.35	**94**	9.17	**56**
Rumex tenuifolius	12.81	**88**	4.95	**37**	3.41	**80**	1.08	**48**	1.71	**57**	2.54	**79**	0.66	**61**	2.60	**52**	6.39	**50**
Scleranthus perennis	8.76	**85**	3.72	**53**	1.17	**17**	1.66	**45**	3.80	**55**	1.05	**34**	2.00	**55**	5.44	**54**	3.07	**72**
Logfia minima	7.96	**79**	3.21	**45**	3.58	**50**	0.31	**13**	0.32	**22**	1.42	**14**	0.16	**6**	0.73	**15**	0.01	**11**
Hypochoeris radicata	4.02	**77**	2.10	**68**	1.70	**59**	0.08	**2**	0.71	**51**	1.09	**72**	0.34	**42**	0.26	**32**	4.74	**61**
Artemisia campestris ssp. *campestris*	3.22	**60**	4.04	**80**	0.48	**11**	5.28	**84**	4.87	**90**	6.16	**100**	4.95	**82**	6.83	**92**	2.53	**83**
Jasione montana	2.50	**80**	2.23	**83**	2.60	**80**	3.18	**81**	1.82	**65**	0.01	**7**	0.20	**45**	1.20	**68**	-	**-**
Trifolium arvense	1.34	**38**	0.41	**23**	0.01	**6**	1.21	**30**	3.67	**78**	3.57	**93**	1.25	**61**	5.77	**92**	3.07	**72**
Helichrysum arenarium	2.39	**42**	1.18	**37**	0.11	**15**	3.61	**84**	2.27	**61**	-	**-**	0.17	**24**	3.35	**22**	-	**-**
Sedum acre	0.56	**12**	0.14	**6**	0.01	**6**	0.49	**13**	0.72	**22**	10.54	**97**	3.36	**67**	7.41	**54**	-	**-**
Festuca trachyphylla	0.23	**10**	0.52	**23**	0.01	**6**	0.48	**28**	0.33	**27**	0.18	**10**	0.48	**30**	1.33	**42**	-	**-**
Rumex acetosella	0.21	**23**	0.25	**22**	0.10	**4**	0.48	**43**	0.15	**53**	0.20	**34**	1.40	**67**	0.20	**43**	3.08	**33**
Cerastium arvense	0.04	**2**	-	**-**	-	**-**	0.08	**1**	0.01	**10**	0.54	**28**	0.16	**15**	-	**-**	0.03	**28**
Sedum maximum	0.01	**2**	0.09	**3**	0.01	**4**	0.33	**36**	0.11	**10**	0.02	**21**	0.02	**15**	0.02	**14**	-	**-**
Herniaria glabra	0.01	**3**	0.01	**2**	-	**-**	-	**-**	0.01	**2**	0.01	**3**	-	**-**	0.01	**3**	-	**-**
Knautia arvensis	0.22	**34**	0.23	**46**	0.01	**11**	0.28	**58**	0.38	**65**	1.10	**86**	0.53	**85**	0.37	**63**	0.03	**28**

Table 1 (continued)

Cerastium semidecandrum	0.15	**19**	0.51	**28**	0.01	**2**	0.05	**22**	0.32	**22**	2.88	**66**	0.21	**58**	1.02	**45**	0.29	**17**
Astragalus arenarius	0.16	**5**	0.22	**12**	0.01	**2**	3.64	**60**	2.51	**20**	3.47	**72**	5.25	**79**	0.51	**14**	-	**-**
Potentilla argentea	0.09	**20**	0.11	**15**	0.01	**4**	0.23	**7**	0.13	**24**	0.26	**55**	1.17	**45**	3.30	**69**	7.93	**72**
Scleranthus polycarpos	0.17	**10**	0.35	**6**	-	**-**	0.23	**10**	-	**-**	0.36	**24**	0.02	**15**	-	**-**	-	**-**
Dianthus deltoides	-	**-**	0.01	**2**	-	**-**	-	**-**	0.01	**2**	-	**-**	0.01	**9**	0.08	**6**	-	**-**
Polytrichum piliferum	12.20	**74**	25.07	**91**	23.94	**89**	20.55	**94**	28.22	**100**	17.41	**69**	18.42	**85**	10.96	**65**	11.00	**56**
Ceratodon purpureus	9.09	**92**	11.97	**69**	10.47	**75**	9.08	**75**	6.29	**59**	7.25	**59**	7.43	**64**	13.62	**86**	11.81	**72**
Niphotrichum ericoides	1.65	**22**	1.67	**20**	0.42	**4**	11.57	**63**	4.90	**43**	11.90	**45**	10.24	**73**	15.25	**89**	11.12	**72**
Cladonia furcata var. *palamaea*	0.54	**22**	0.05	**4**	0.48	**22**	0.69	**33**	1.00	**41**	0.18	**14**	0.33	**36**	0.17	**14**	-	**-**
Cladonia subulata	0.07	**6**	3.54	**52**	0.61	**13**	1.30	**35**	2.00	**37**	0.01	**3**	0.15	**3**	0.94	**25**	0.57	**22**
Cladonia phyllophora	0.30	**8**	-	**-**	0.33	**7**	0.15	**5**	0.78	**27**	0.01	**3**	0.16	**6**	0.08	**2**	0.01	**11**
Cladonia scabriuscula	0.01	**1**	0.01	**1**	0.19	**6**	-	**-**	0.21	**10**	-	**-**	-	**-**	-	**-**	-	**-**
Cladonia glauca	-	**-**	-	**-**	-	**-**	0.31	**9**	0.01	**12**	-	**-**	-	**-**	-	**-**	-	**-**
Cetraria islandica	-	**-**	-	**-**	-	**-**	0.01	**2**	-	**-**	-	**-**	0.53	**6**	-	**-**	-	**-**
Other species																		
Agrostis capillaris	4.97	**75**	0.34	**26**	0.82	**43**	0.80	**22**	1.56	**49**	0.35	**14**	0.93	**33**	2.11	**51**	1.26	**100**
Anthoxanthum odoratum	0.09	**11**	0.51	**32**	0.63	**20**	0.82	**3**	0.95	**47**	0.02	**17**	0.17	**24**	0.17	**17**	0.01	**11**
Plantago lanceolata	0.01	**5**	0.15	**18**	0.01	**4**	0.09	**16**	0.32	**16**	0.89	**48**	0.81	**67**	0.51	**54**	2.80	**50**
Solidago virgaurea	0.01	**2**	-	**-**	0.01	**9**	0.20	**32**	0.01	**8**	-	**-**	0.02	**21**	0.02	**15**	-	**-**
Myosotis stricta	0.02	**17**	1	**3**	-	**-**	0.02	**15**	0.02	**22**	0.01	**14**	0.02	**21**	0.01	**5**	-	**-**
Cladonia fimbriata	0.86	**25**	1.45	**24**	0.28	**6**	0.85	**30**	0.14	**43**	1.31	**34**	0.17	**27**	0.48	**31**	0.03	**28**
Cladonia gracilis	1.01	**12**	-	**-**	-	**-**	-	**-**	0.42	**14**	-	**-**	0.01	**9**	0.15	**3**	-	**-**
Peltigera rufescens	0.04	**1**	0.01	**4**	-	**-**	0.01	**2**	0.21	**14**	0.01	**10**	0.15	**3**	-	**-**	0.01	**6**

creating such a system will be a difficult task because grey-hair grass communities develop under both maritime and continental climates, which are likely responsible for their floristic diversity.

In European phytosociology, the concept of diagnostic species has been associated with fidelity, which is a measure of species concentration in vegetation units. Diagnostic species are first classified by a numerical method and then species with the highest concentration in particular vegetation units are determined to be diagnostic (CHYTRÝ et al. 2002). Another differential species criterion was presented by DENGLER (2003) – a species can be called differential for one syntaxon versus another syntaxon of the same rank if its constancy is at least twice as high and difference in commonness is not likely due to chance alone. This formulation uses constancy percentages instead of constancy classes. Only those taxa having at least 20% constancy within the particular syntaxon and not more than 20% in the compared syntaxa should be given the status of differential species. In my paper the species treated as differential taxa fit this criterion, except *Festuca ovina*, which plays a major role in the subtypes with *Thymus serpyllum* and with *Festuca ovina* (see Table 1). This is why it is not a good differential species. However, in the ranking of TWINSPAN, relevés representing the community with *Festuca ovina* were split into separate groups on that basis. Classifications of dry grassland communities in Poland by W. MATUSZKIEWICZ (2001), in Mecklenburg-Vorpommern (DENGLER 2004) and in the Czech Republic (CHYTRÝ 2007) are slightly different in the sets of diagnostic species, e.g. in the German classification *Cerastium glutinosum*, *C. pumilum*, *Peltigera rufescens* are considered to be character species for class *Koelerio-Corynephoretea*; *Cladonia glauca*, *Placynthiella oligotropha*, *P. uliginosa*, *Trapeliopsis granulosa* are character taxa for order *Corynephoretalia canescentis; Agrostis capillaris* is differential species for order; and *Cetraria islandica* is a character species for the alliance *Corynephorion*. In the classification used in Poland, none of these species is considered to be a characteristic one for any of the ranks. However, *Agrostis vinealis* and *Potentilla collina*, for example are treated as character species for the class *Koelerio-Corynephoretea* in Poland, whereas in DENGLER (2001) *A. vinealis* is considered a character species restricted to the *Agrostietum vinealis* and *Potentilla collina* is absent from the *Koelerio-Corynephoretea*.

The fact that it is difficult to determine diagnostic species has also been indicated by LÖBEL & DENGLER (2008), who reported that *Thymus serpyllum* ssp. *serpyllum*, *Festuca ovina* and *Cladonia rangiformis* are species restricted to the *Koelerio-Corynephorenea* (Klika in Klika & V. Novák 1941) Dengler in Dengler et al. 2003 in central Europe, show a wide amplitude in Scandinavia and occur there in three high-rank syntaxa of dry grasslands – *Koelerio-Corynephorenea*, *Sedo-Scleranthenea* (Br.-Bl. 1955) Dengler in Dengler et al. 2003 and *Festuco-Brometea* Br.-Bl. & Tx. ex Klika & Hadač 1944. These examples demonstrate that further studies are necessary and should include critical verification of phytosociological materials gathered from all areas supporting psammophilous grasslands.

In this paper, complying with the classification by W. MATUSZKIEWICZ (2001), *Spergula morisonii*, *Teesdalia nudicaulis* and *Veronica dillenii* were taken as character species for the association *Corniculario-Corynephoretum*. Although the last of these taxa occurs in grey-hair grass communities only locally in Poland, it is a common element of dry grasslands in the Masurian Lake District. According to CZYŻEWSKA (1992) the community is present throughout lowland Poland. In the west, north-west and north of Poland, this phytocenosis represents the subatlantic variant (with *Carex arenaria*), whereas in the Masurian Lake District it corresponds to the subcontinental variant with *Veronica dillenii*. Therefore, these two species have been assumed to distinguish two variants of the association (geographical races; see also JUŚKIEWICZ 1999). Among character species (according to W. MATUSZKIEWICZ 2001) of the alliance *Corynephorion canescentis* the following were common in the grey-hair grass community in the Masurian Lake District: *Cladonia arbuscula* ssp. *mitis*, *C. cervicornis* ssp. *verticillata; Cetraria aculeata* was less common and *Cephaloziella starkei*, *Cladonia floerkana*, *C. macilenta*, C. *uncialis*, *Cetraria muricata* occurred only sporadically. The order *Corynephoretalia canescentis* and the class *Koelerio-Corynephoretea* were often represented by *Corynephorus canescens*, *Festuca ovina*, *Helichrysum arenarium*, *Jasione montana*, *Cerastium semidecandrum*, *Rumex* *acetosella*, *R. tenuifolius*, *Scleranthus perennis*, *Sedum acre*, *Ceratodon purpureus* and *Polytrichum piliferum*. *Hieracium pilosella* was recognized as a further character taxon of the class (according to CZYŻEWSKA 1992), along with *Scleranthus polycarpos*, *Cetraria islandica* and *Peltigera rufescens* (according to DENGLER 2004). Moreover, *Myosotis stricta*, *Cladonia gracilis*, *C. fimbriata* were taken as differential taxa of the class (according to DENGLER 2004).

It is characteristic for the *Corniculario-Corynephoretum* in the Masurian Lake District that atlantic elements typical of higher-rank syntaxa in Northern Germany (DENGLER 2001) are very rare (*Cetraria muricata* and *Carex arenaria* are encountered sporadically) or absent (*Ornithopus perpusillus, Hypochoeris glabra*; see Table 1).

The examined association had a two-layered structure. The herbaceous layer was best developed in the *Cladonia arbuscula* ssp. *mitis* variant of the subtype with *Thymus serpyllum* (up to 96% cover), while the lichen-moss layer was most abundant in the *Cladonia arbuscula* ssp. *mitis* variant of the subtype with *Thymus serpyllum* (65%) and the subtype with *Cladonia arbuscula* ssp. *mitis* (53–57%). The stands also comprised saplings – *Pinus sylvestris* was encountered most frequently in the *Polytrichum piliferum* variant of the typical subtype and the subtype with *Cladonia arbuscula* ssp. *mitis* (JUŚKIEWICZ 1999).

The following species reached their ecological optimum (see mean cover values in Table 1) in this subassociation: *Spergula morisonii, Corynephorus canescens, Rumex tenuifolius, Scleranthus perennis, Hypochoeris radicata,* and *Conyza canadensis*. The lichen-moss layer was dominated by *Polytrichum piliferum* and *Ceratodon purpureus*, accompanied by *Cladonia subulata*, *C. fimbriata* and the pioneer forest species *C. cornuta* and *C. gracilis*. The variant with *Hypochoeris radicata*, rare in northeastern Poland, resembles the subtype with *Festuca ovina* floristically. The variant with *Artemisia campestris* was quite frequent.

The subtype with *Cladonia arbuscula* ssp. *mitis* represented the optimal stage of grey-hair grass communities on the poorest acidic sand. The grasslands of this subtype were dense and homogenous, and had a well-developed lichen-moss layer dominated by *Cladonia arbuscula* ssp. *mitis, C. cervicornis* ssp. *verticillata, C. uncialis, Cetraria aculeata, Polytrichum piliferum* and *Niphotrichum ericoides*. Among all grassland types described in this paper, this subassociation contained the largest number of non-vascular plant species (14 taxa). In the typical variant, bryophytes and lichens were accompanied by quite abundant *Astragalus arenarius* and *Helichrysum arenarium.* In the variant with *Polytrichum piliferum,* the name-giving species dominated the ground layer where it reached its ecological optimum.

The subtype with *Thymus serpyllum* had the richest floristic composition. This phytocenosis was marked by high cover values in the herbaceous layer (94–96%) and in the lichen-moss layer (40–60%). *Thymus serpyllum* had its ecological optimum in the herbaceous layer, where *Festuca ovina* was also quite frequent. Among non-vascular plant species, *Polytrichum piliferum, Niphotrichum ericoides* and *Cladonia arbuscula* ssp. *mitis* contributed most to the formation of phytocenosis. The considerable abundance of these species provided a basis for distinguishing between particular variants.

Grasslands classified as the subtype with *Festuca ovina* exhibited a high degree of floristic similarity to the subtype with *Thymus serpyllum*, which points to the relationships between these syntaxa. The subtype with *Festuca ovina* was dominated by grasses, primarily *Festuca ovina, Agrostis capillaris, Corynephorus canescens* and *Festuca trachyphylla.* Other frequent components were *Artemisia campestris* and *Helichrysum arenarium*, while *Thymus serpyllum* was encountered sporadically. Taking into account species combination, relevés dominated by *Festuca ovina* were classified either in the subtype with *Thymus serpyllum* or in the subtype with *Festuca ovina*. The floristic composition of the subtype with *Festuca ovina* resembles that of the *Spergulo-Corynephoretum festucetosum ovinae* described by KRAUSCH (1968). According to CZYŻEWSKA (1992) the subtype with *Thymus serpyllum* and the subtype with *Festuca ovina* appear in the same habitats. Accordingly, they should be treated as vicariants. Doubtlessly, the syntaxonomic range of these communities could be subject to discussion. According to several vegetation ecologists (e.g. DENGLER 2004), the relevés dominated by *Festuca ovina* should rather be placed in the other syntaxa, namely in the alliances *Armerion elongatae* Pötsch 1962 (order *Trifolio-arvensis-Festucetalia ovinae* Moravec 1967) or *Koelerion glaucae* Volk 1931 (order *Sedo acris-Festucetalia* Tx. 1951 nom. invers. propos.). However, the major role of the presumed character species of the association (Tab. 1) justifies also placing these relevés in the *Corniculario-Corynephoretum*.

A larger species diversity observed in the Masurian Lake District could be explained by the fact that not all of the recorded species were typical psammophytes – some of them were accidental species of various origin. The presence of such species in open, unstable biocenoses appears to be a natural phenomenon (CZYŻEWSKA 1992).

4.3. Characteristics of habitats in psammophilous grasslands

In the Masurian Lake District, the *Corniculario-Corynephoretum* occupies secondary habitats, including forest clearings, roadside banks, abandoned fields and former gravel pits, i.e. sunny, dry, flat to hilly sites, usually with S, SE or E aspect. The typical subtype preferred typical arenosols. The habitats preferred by the subtype with *Cladonia arbuscula* ssp. *mitis* are very dry, most often with a slight inclination (2–15°). The subtype with *Thymus serpyllum* developed on flat to hilly areas, with slope angles reaching 60°, differing in the duration of sunlight exposure, on rusty soils belonging to the group of podsols formed from loose or slightly loamy sand. Rusty brown soils and pararendzinas, developed from loose and slightly loamy sand, are preferred by the subtype with *Festuca ovina*. In the study area, this soil contained 1% of $CaCO_3$ and their reaction ranged from acidic (pH 4.5) to nearly neutral (pH 6.2). The properties of the soils with occurrences of the *Corniculario-Corynephoretum* are specified in Table 2.

Table 2: Description of exemplary soil profiles from various subunits of the *Corniculario-Corynephoretum* in the Masurian Lake District. "–" stands for values below limit of provability.

Tab. 2: Beschreibung von exemplarischen Bodenprofilen unter verschiedenen Untereinheiten des *Corniculario-Corynephoretum* in der Masurischen Seenplatte. „–" steht für Werte unter der Nachweisgrenze.

Syntaxonomic unit	Number of relevé	Number of profile	Depth of sample (cm)	Horizon	pH (in H_2O)	pH (in KCl)	H (cmol/kg)	S (cmol/kg)	CEC (cmol/kg)	C (%)	$CaCO_3$ (%)	Soil type
Typical subtype, variant with *Artemisia campestris*	296	1	5–10	A	7.16	6.10	0.52	3.02	3.54	0.78	–	proper arenosol on a relic rusty soil
			25–30	A/C	4.95	4.00	3.20	2.50	5.70	0.10	–	
			45–50	Are	5.06	4.11	2.37	1.09	3.46	–	–	
			60–65	Bvre	5.17	4.22	1.80	0.97	2.77	–	–	
Subtype with *Cladonia arbuscula* ssp. *mitis*, typical variant	325	2	10–15	A	5.24	4.30	3.11	2.20	5.31	0.85	–	proper arenosol
			45–50	C	6.01	5.04	1.29	1.14	2.43	–	–	
	91	3	6–11	A	5.94	4.98	3.12	1.80	4.92	0.88	–	proper arenosol
			16–21	A/C	6.53	5.61	2.63	1.58	4.21	0.23	–	
			50–55	C	6.60	5.67	1.02	1.09	2.11	–	–	
Subtype with *Thymus serpyllum*, variant with *Cladonia arbuscula* ssp. *mitis*	205	4	5–10	A	6.58	5.62	2.79	2.90	5.69	0.86	–	proper arenosol on a brown pararendzina
			25–30	A/C	8.12	7.20	0.34	2.16	2.50	0.11	–	
			55–60	Bk	8.09	7.10	0.15	2.07	2.22	–	< 1	
Subtype with *Thymus serpyllum*, variant with *Festuca ovina*	109	5	10–15	ABv	5.02	4.08	3.27	1.75	5.02	0.81	–	proper rusty soil
			30–35	Bv	5.46	4.50	2.54	1.40	3.94	0.15	–	
			50–55	C	6.09	5.12	1.26	1.12	2.38	–	–	
Subtype with *Festuca ovina*, typical variant	80	6	5–10	Aan	7.14	6.38	0.41	5.20	5.61	0.97	–	anthropogenic pararendzina
			25–30	A/Ccaan	8.34	7.45	0.27	5.61	5.88	0.26	1	
			55–60	C	7.73	6.91	0.11	2.03	2.14	–	–	
	276	7	5–10	A	5.57	4.60	2.70	2.94	5.64	0.98	–	brownish rusty soil
			20–25	ABbrBv	5.75	4.82	2.13	2.56	4.69	0.32	–	
			50–55	C	6.29	5.33	0.94	2.08	3.02	–	–	

4.4. Current state of psammophilous grasslands in the Masurian Lake District

The association *Corniculario-Corynephoretum* represents the earliest stage of vegetation development, yet it plays an important biological role as it initiates certain ecological processes, stabilizes loose sands (thus preventing wind erosion), starts soil-forming processes and prepares the substrate for further succession stages, and contributes to landscape diversity. Since psammophytes are adapted to survive the hardest conditions, psammophilous grasslands are known for their high self-renewal capacity (CZYŻEWSKA 1992). This study revealed that these communities are relatively rare, cover small areas and are exposed to human pressure. The follow-up research carried out 14 years later pointed to a decrease in the total area occupied by the association *Corniculario-Corynephoretum* (Fig. 1). While analyzing the occurrence of par-

Fig. 2: *Corniculario-Corynephoretum*, typical subtype. Dry grassland seasonally used as a sports field in the village of Wymój, Masurian Lake District (Photo: Barbara Juśkiewicz-Swaczyna, July 2008).

Abb. 2: Typische Ausbildung des *Corniculario-Corynephoretum.* Saisonal genutzter Sportplatz mit Trockenrasen im Dorf Wymój, Masurische Seenplatte (Foto: Barbara Juśkiewicz-Swaczyna, Juli 2008).

Fig. 3: *Corniculario-Corynephoretum*, typical subtype. Dry grassland overgrown with self-sown *Pinus sylvestris* – an example of natural succession – near the village of Wymój – Masurian Lake District (Photo: Barbara Juśkiewicz-Swaczyna, July 2008).

Abb. 3: Typische Ausbildung des *Corniculario-Corynephoretum.* Trockenrasen mit Naturverjüngung von *Pinus sylvestris* – ein häufiges Beispiel für natürliche Sukzession, nahe Wymój, Masurische Seenplatte (Foto: Barbara Juśkiewicz-Swaczyna, Juli 2008).

Fig. 4: *Corniculario-Corynephoretum*, subtype with *Cladonia arbuscula* ssp. *mitis*, variant with *Polytrichum piliferum*. Tree removal aimed at preserving open grassland phytocenoses in the village of Giedajty, Masurian Lake District (Photo: Barbara Juśkiewicz-Swaczyna, July 2008).

Abb. 4: *Corniculario-Corynephoretum*, Ausbildung mit *Cladonia arbuscula* ssp. *mitis*, Variante mit *Polytrichum piliferum.* Beseitigung von Bäumen als Maßnahme zur Erhaltung der offenen Sandtrockenrasen im Dorf Giedajty, Masurische Seenplatte (Foto: Barbara Juśkiewicz-Swaczyna, Juli 2008).

Fig. 5: *Corniculario-Corynephoretum*, subtype with *Cladonia arbuscula* ssp. *mitis*, variant with *Polytrichum piliferum*. Well-preserved dry grassland in the village of Wymój, Masurian Lake District (Photo: Barbara Juśkiewicz-Swaczyna, July 2008).

Abb. 5: *Corniculario-Corynephoretum*, Ausbildung mit *Cladonia arbuscula* ssp. *mitis*, Variante mit *Polytrichum piliferum.* Gut erhaltener Trockenrasen im Dorf Wymój, Masurische Seenplatte (Foto: Barbara Juśkiewicz-Swaczyna, Juli 2008).

Table 3: Occurrences of the different subunits of the *Corniculario-Corynephoretum* in the Masurian Lake District in the years 1994–2008.

Tab. 3: Vorkommen der Untereinheiten des *Corniculario-Corynephoretum* in der Masurischen Seeplatte in den Jahren 1994–2008.

Subtype	Typical Subtype			Subtype with *Cladonia arbuscula* ssp. *mitis*		Subtype with *Thymus serpyllum*		Subtype with *Festuca ovina*	
Variant	Typical variant	Variant with *Hypochoeris radicata*	Variant with *Artemisia campestris*	Typical variant	Variant with *Polytrichum piliferum*	Variant with *Cladonia arb.* subsp. *mitis*	Variant with *Festuca ovina*	Typical variant	Variant with *Agrostis capillaris*
1. Pelnik	■▲	■	■	.	▲	.	.	.	.
2. Wrzesina	■▲	■▲	■▲	.	■	.	.	.	.
3. Warkały	■▲	■	■▲	■	.	.	.	.	.
4. Olsztyn	■	■	■	■	■	■	■	■	■
5. Łupsztych	.	.	.	.	■	.	■	■	.
6. Kromerowo	■▲	.	■▲	.	.	.	■▲	■	.
7. Stękiny	.	■	■	.	.	.	.	.	.
8. Giedajty	▲	.	.	■▲	▲	.	.	.	.
9. Naglady	■▲	■	■		▲	.	.	.	.
10. Rapaty	■▲	■	■	■▲	■	.	■	■	.
11. Kręsk	■▲	.	.	.	■▲	.	.	.	.
12. Krzywonoga	.	■	■	.	▲	.	.	■	.
13. Nowa Wieś	.	■	■	.	.	.	.	.	.
14. Zgniłocha	■▲	.	.	.	■▲	.	.	.	.
15. Wymój	■▲	■▲	■▲	■	■▲	.	■	■	.
16. Gryźliny	■▲	.	.	.	■▲	.	■	.	.
17. Miodówko	■▲	.	.	.	■▲	.	.	.	.
18. Zielonowo	▲	.	.	■	■	.	.	■	.
19. Pluski	■▲	.	■	■▲	.	■	■	■	.
20. Stara Kaletka	.	■▲	.	.	.	.	.	■	.
21. Czarny Piec	■▲	.	■	■▲	■▲	.	■	■	.
22. Złote Góry	■▲	.		■▲	■▲	■▲	.	.	.
23. Jagarzewo	.	.	■	.	▲	.	.	.	.
24. Muszaki	.	■	.	.	.	.	.	■	.

■ 1994–1997 ▲ 2008

ticular variants of this association at selected sites (Table 3), attention should be paid to the gradual disappearance of numerous plots of the *Corniculario-Corynephoretum*. This phenomenon is particularly noticeable in towns and villages like Olsztyn, Łupsztych, Stękiny, Nowa Wieś and Muszaki, where such grasslands are practically non-existent today, mainly due to urban development and afforestation. Fourteen years ago, a great variety of grassland types could be observed in the city of Olsztyn, including different subtypes of *Corniculario-Corynephoretum* reported from five quarters. The stands were located in a scenic district, close to lakes. Since then this land has been used for housing development and road construction.

The most common reasons for the decline or disappearance of psammophilous grasslands in the Masurian Lake District include their use for the purposes of residential housing, road construction, planned afforestation, sand extraction, wood storage and unauthorized dumping, as well as the flooding of gravel pits. In contrast to the above types of land use, seasonal use of grasslands for recreational purposes (as sunbathing spots or as sports fields) (Fig. 2) does not lead to their degradation and may have a beneficial influence on their maintenance as a component of the local landscape, as seen in the villages of Pluski, Kromerowo or Zielonowo. The decrease in grassland areas is also a consequence of natural succession, which involves their overgrowing by self-sown trees, primarily *Pinus sylvestris*, as observed in the villages of Pelnik, Wymój (Fig. 3), Krzywonoga or Gryźliny.

Well-preserved communities dominated by grey-hair grass can be found at very few localities in the villages of Giedajty and Naglady, where the area is regularly cleared of invading trees (Fig. 4). This contributes to grassland preservation and helps to increase their diversity. The best preserved patches, covering the largest areas (1,000–2,000 m^2), are located in the villages of Warkały, Pelnik, Kręsk and Wymój (Fig. 5). However, their survival is seriously threatened since the land will most probably be zoned for single-family and cottage housing.

Unfortunately, the environmental importance of dry grasslands is often underevaluated, and such communities are at increased risk from anthropogenic pressure. The adverse human impact on psammopilous and xerothermic grasslands in regions other than the Masurian Lake

District have been described by numerous authors, including STEFFEN (1931), GŁOWACKI (1975), SOKOŁOWSKI & KAWECKA (1984), and CEYNOWA-GIEŁDON (1986).

The results of my studies on psammophilous grasslands in the Masurian Lake District contradict those of MŁYNKOWIAK & KUTYNA (2005), who postulated that the original area of *Corniculario-Corynephoretum* was smaller than today due to habitat limiting factors. According to the above authors, the concerted effect of various anthropogenic factors has led to secondary expansion of this semi-natural pioneer community, and to a several-fold increase in its total area. It should be stressed that psammophilous grasslands with *Corynephorus canescens* are continuously exposed to strong human pressure in the Masurian Lake District, and this limits their distribution. The conservation of psammophilous grasslands is rather difficult due to the fact that the areas they occupy are treated as wasteland. Habitat protection under the Natura 2000 network would help to preserve psammophilous grasslands, which are a unique component of the young glacial landscape.

Well-preserved grassland patches in the area of Złote Góry ("Golden Mountains") will be protected as part of Napiwoda-Ramuki Forest. These grasslands occur in the form of large plots, covering around 41 ha. Inland sand dunes with psammophilous grasslands of the alliance *Corynephorion canescentis* (Type 2330 of the Habitats Directive; see EUROPEAN COMMISSION 2007) and with xerothermic psammophilous grasslands of the alliance *Koelerion glaucae* (Type 6120) will be protected within the site of Murawy, the Military Training Grounds in Orzysz. Preliminary field investigations conducted in 2008 in the military training grounds in Orzysz have demonstrated that the *Corniculario-Corynephoretum* is extremely rare and covers very small areas within this site, collectively only 1.6 ha. The grasslands belonging to the alliance *Koelerion glaucae* are much larger, as they cover 520 ha.

A detailed inventory of plant communities is underway on the areas that are planned to become protected nature sites. In 2009, plans for protection of these areas will be drawn up.

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