Anna PASZKIEWICZ-JASIŃSKA, Marek HELIS
Institute of Technology and Life Sciences Lower Silesia Research Centre in Wrocław
Lower Silesia Research Centre
e-mail: paszkiewicz.anna@gmail.com, a.paszkiewicz@itp.edu.pl, m.helis@itep.edu.pl

FLORISTIC DIVERSITY OF MEADOW AND PASTURE COMMUNITIES LOCATED IN THE KŁODZKO COUNTY COMPARED WITH THE ENVIRONMENTAL FACTORS

Summary

The paper presents the phytosociological structure of selected meadows and pastures used agriculturally, located in Kłodzko County, versus environmental factors. The communities of researched grasslands were classified into Molinio-Arrhenatheret class and two orders: Molinietalia i Arrhenatheretalia. Four groups were distinguished: Angelico-Cirsietum oleracei, Arrhenatheretum elatioris, Lolio-Cynosuretum and Festuco-Cynosuretum, as well as three communities with dominant species: Poa pratensis-Festuca rubra community, community with Agrostis capillaris-Festuca rubra and community with Trisetum flavescens. Those communities exhibit a rich species diversity, expressed in an average number of species in a phytosociological study (21–25). The greatest number of species was found for community with Agrostis capillaris-Festuca rubra and Festuco-Cynosuretum. The analysed pasture and meadow communities were created mainly on mountainsides with a considerable slope (above 6°) and diverse sunlight exposure, on brown and spodic soils, occurring mainly in the Sudety Mountains. The average sunlight exposure indicates to a thermophilism of distinguished communities.
***Key words**: pasture and meadow communities, Kłodzko County, environmental factors, GIS*

ZRÓŻNICOWANIE FLORYSTYCZNE ZBIOROWISK ŁĄKOWO-PASTWISKOWYCH W WYBRANYCH MIEJSCACH W POWIECIE KŁODZKIM W ODNIESIENIU DO CZYNNIKÓW PRZYRODNICZYCH

Streszczenie

W pracy przedstawiono strukturę fitosocjologiczną wybranych łąk i pastwisk, wykorzystywanych rolniczo, usytuowanych w powiecie kłodzkim, na tle czynników przyrodniczych. Zbiorowiska badanych użytków zielonych zaklasyfikowano do klasy Molinio-Arrhenatheretea i dwóch rzędów: Molinietalia i Arrhenatheretalia. Wyróżniono cztery zespoły: zespół Angelico-Cirsietum oleracei, zespół Arrhenatheretum elatioris, zespół Lolio-Cynosuretum i zespół Festuco-Cynosuretum oraz trzy zbiorowiska z gatunkiem dominującym: zbiorowisko Poa pratensis-Festuca rubra, zbiorowisko z Agrostis capillaris-Festuca rubra oraz zbiorowisko z Trisetum flavescens. Zbiorowiska te charakteryzowały się zróżnicowanym bogactwem gatunkowym, wyrażonym średnią liczbą gatunków w zdjęciu fitosocjologicznym (od 21 do 25). Największą liczbę gatunków, stwierdzono dla zbiorowiska z Agrostis capillaris-Festuca rubra i zespołu Festuco-Cynosuretum. Wyróżnione zbiorowiska łąkowo-pastwiskowe wykształciły się najczęściej na stokach o znacznym nachyleniu (powyżej 6°) i o zróżnicowanej ekspozycji, na glebach brunatnych i bielicowych, najczęściej spotykanych w Sudetach. Średnia wartość promieniowania całkowitego wskazuje na ciepłolubność wyróżnionych zbiorowisk.
***Słowa kluczowe**: zbiorowiska łąkowo-pastwiskowe, powiat kłodzki, czynniki przyrodnicze, GIS*

1. Introduction

The area which researches the diversity of botanical composition of grasslands and occurrence of recurring patterns (communities) is called meadow phytosociology. The results of phytosociological research are used in the assessment of productivity, environmental valorisation and evaluation of settlement conditions. Moreover, they are used in order to draw up area development plans, and to assess the impact on the environment as well as to create protection plans.

Species composition of plant communities on grasslands located in the moderate climate zone depends mainly on environmental and anthropogenic factors.

Among the settlement factors one can distinguish soil factors, and, in mountainous regions, topographic factors, considered as absolute height and sunlight exposure of slopes. The influence of topographic factors on flora was defined in the work of Howard and Mitchell as phytogeomorphology [1]. After the consideration of various factors of floral production, phytogeomorphology may be implemented for increase yield [2]. The research on grasslands conducted in Poland and abroad indicates a dependency between occurrence of heterogeneous grass patches and landform and soil thickness [3, 4, 5].

The main soil factors are: nitrogen and phosphorus saturation and soil pH, while the slope and exposure influence the value of sunlight and are important factors determining the purpose of use of the terrain.

The aim of the paper is to present a phytosociological characteristics of meadows and pastures used in extensive way, located on farmlands located in the Kłodzko County, against the environmental factors.

2. The area of research

Kłodzko County (164,000 ha) is located in the south-west part of Poland, in Lower Silesian Viovodeship and it is one of 4 Counties located in the Sudety area. According to the Kondracki physical-geographical division [6], it is located in the Czech Massif province, Sudety and Sudety Foreland subprovince, in macroregions: the Central and Eastern Sudety.

The entire area of the County is considerably diverse in case of physiogeography. Its western part consists of the Central Sudety, while the eastern part is located in the Eastern Sudety Mountains. Its central part is located in the Kłodzko Valley, which is surrounded with the Bardzkie Mountains in the north, the Stołowe Mountains in the west, and Złote Mountains, together with Śnieżnik Massif and Krowiarki, belonging to the Estern Sudety, in the east.

As a result of the climate conditions, the area of the County belongs to two pluviothermal regions: Wałbrzych and Kłodzko [7]. The Wałbrzych region displays severe climate conditions, and is located in two altitude zones of agriculture usability: zone b – moderately warm, reaching up to 550 m.a.s.l., with an average annual temperature of air of 6.1°C, and annual precipitation from 700 to 800 mm, and zone c – moderately cold, above 550 m.a.s.l., considered as not agriculturally useful because of lack of a thermal summer period and high (above 800 mm) annual precipitation. The Kłodzko region is more favourable in case of climate conditions than the Wałbrzych region and it displays a relatively moderate climate. Three altitude zones were distinguished in the region: zone a – reaching up to 400 m.a.s.l. – the most favourable zone for agriculture in the entire Sudety region, as the average annual air temperature reaches there 7.4°C and annual precipitation amounts to 700 mm; zone b (400-600 m.a.s.l.) is cooler, as the annual temperature amounts there from 6 to 6.6 °C, and the precipitation varies from 700 to 1000 mm. Zone c (600-800 m.a.s.l.) is an area unfavourable for agriculture, with an average annual temperature of 4.9°C and annual precipitation reaching 700 mm.

In the Kłodzko County, according to the latest Agricultural Census [8], permanent grasslands cover the area of 20,390 ha (including pastures 5,173 ha). They are mainly lands with mediocre quality included in 2z soil-agricultural type (65%). Above 30% of permanent grasslands belong to 3z type (34%) – lands which are of poor and very poor quality and 1% of lands display very high quality (1z) [9].

Within the borders of the Kłodzko County there are areas which are legally protected. Among the biggest ones there are: Stołowe Mountains National Park together with adjacent protected area (it constitutes 11.0% of the area of the County), Sowie Mountains Landscape Park (27.0%), Śnieżnik Landscape Park (15.7%), Area of Protected Landscape of Bystrzyca and Orlica Mountains (14.0%), Area of Protected Landscape of Bardo and Sowie Mountains (3.3%) and other 19 Areas of Special Protection.

The study included grasslands in majority belonging to farmers associated in 'Wołowina Sudecka' production group, operating on the grounds of Kłodzko County, who breed beef and dairy cattle. The farmlands where the research was conducted are located in the following mesoregions: Nowa Ruda Area, Kłodzko Valley, Bardo Mountains, Orlica Piedmont, Stołowe Mountains, Ścinawka Area, Bystrzyca Mountains (Central Sudety macroregion) as well as Śnieżnik Massif and Złote Mountains (Eastern Sudety macroregion). In the Nowa Ruda Area, the research encompassed meadows and pastures located in Dzikowiec; in Ścinawka Area – Ścinawka Średnia; in Kłodzko Valley – Długopole Górne; on the border between Kłodzko Valley and Bardo Mountains – Boguszyn; on the border between Orlica Piedmont and Stołowe Mountains – Kudowa Zdrój; in Złote Mountains – Lutynia, Trzebieszowice; in Śnieżnik Massif – Jodłów, Marcinków and Nowa Wieś Kłodzka (Fig. 1).

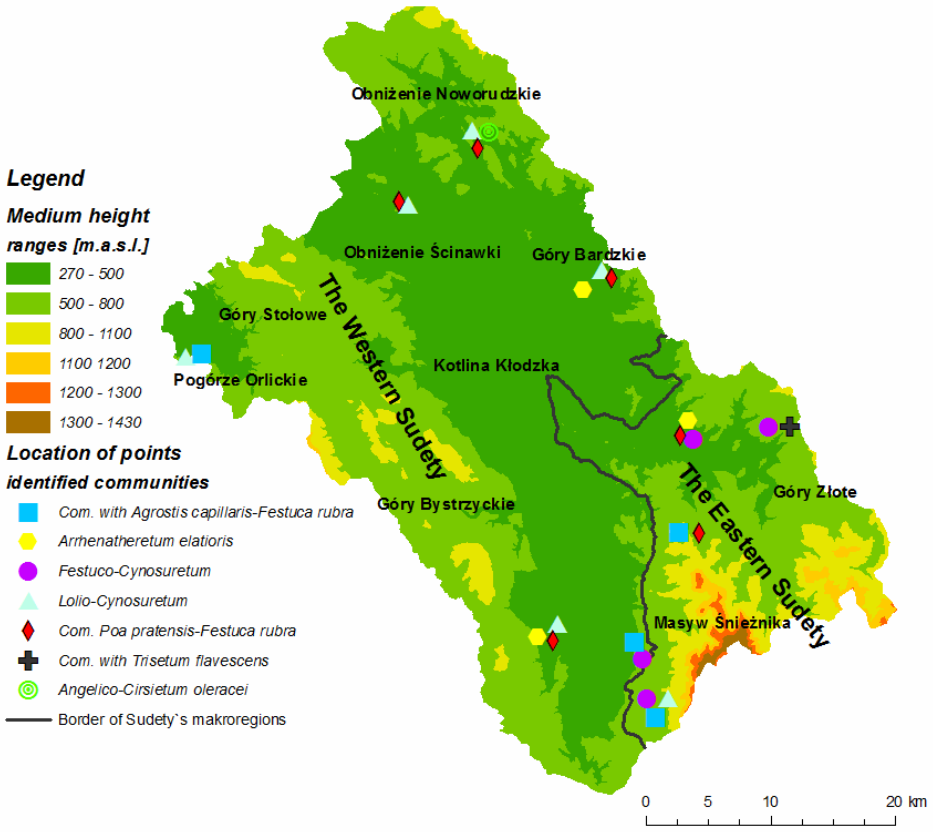

Fig. 1. The research area and location of selected communities
Rys. 1. Teren badań wraz z lokalizacją wyróżnionych zbiorowisk

3. Research Methodology

3.1. Methodology of phytosociologocal research

Within the years 2009-2013 the research of flora in permanent grasslands was conducted in Lower Silesian Research Center in the framework of the statutory tasks led by Longina Nadolna. The field research was conducted using Braun-Blanquet method [10]. 221 conducted phytosociological studies constituted the basis of the aforementioned research and were the main source for the analysis of diversity of vegetation, as well as identification and classification of communities. The decision to affiliate the studies with particular phytosociological tables was made basing on the similarity of species composition as well as quantitative share of species in the same syntaxomic units. The analysis was performed using the Juice computer programme [11]. The syntaxomic affiliation of selected communities was determined in accordance with the Matuszkiewicz method [12]. The Latin names of vascular plants were taken from the work of Mirek et al. [13]. The synthetical phytosociological table created for selected communities presents the number of studies, and, for each species, the phytosociological constant (S) in the scale of I-V or the occurrence (O) as well as the cover index (D) [10]. The species richness is determined based on the average number of species present in a phytosociological study. What is more, the occurrence of species under environmental protection was also reported in the study [14].

3.2. Methodology of cartographic research

In the study we assumed that the environmental factors were data concerning soil factors, ways of the terrain use and Digital Elevation Model (DEM) together with the derivatives (dominant exposition, average slope and sunlight exposure). In order to determine the environmental conditions of the area of research, as a boarder needed for further geographic transformations we assumed circles with a radius of 1 meter, located in places of phytosociological studies. After preparing a phytosociological classification, for particular patches located in selected communities we read the environmental conditions from maps.

The cartographic analyses were conducted on the basis of database of environmental factors from the Institute of Technology and Life Sciences in Lower Silesia Research Centre. The database was expanded and enriched by introducing to it additional theme of layers representing Kłodzko County, including the spatial data concerning classification and types of use of soils and buildings [15].

A vital data required for preparation of characteristics of the researched area is DEM with its derivatives – slope and exposure. The DEM measurement was created using the vector data from the topographic map in the scale of 1:10 000 (National Geodetic System – PUWG 65) [16] with a minimum level cut of 2.5 meters, where the vertices of vectors were substituted with points. Next, a cloud of points obtained in such a way underwent the process of spatial interpolation using the method of ordinary kriging and modified spline method [17]. The created Digital elevation model with the resolution of 10 meters was transformed into its derivatives: exposure and slope. The land use map was prepared using the map of evidence of soils and buildings (in a scale of 1:1000) together with the terrain observations. The data concerning types, kinds and classification of soils were obtained based on a soil-agricultural map in a scale of 1:5000, created by Voivodeship Bureau of Surveying and Agricultural Areas in Wrocław in 1971 [18]. The map was implemented into GIS (Geographic Information System), and next matched with a topographic map. The map of total sunlight exposure was drawn up using the Štružka method [19], which enabled determining approximate, relative values of total sunlight reaching the surface with any exposure and slope expressed in percentage. In the aforementioned method, the sum of total sunlight reaching the horizontal surface was assumed as 100%. The map was created using parametric transformations of intervals of both slope and exposure according to the algorithm described by Štružka. The data were used to develop the final map, on which there were assigned the surfaces of slopes with specific value of sunlight exposure expressed in percentage.

The prepared maps were used to read the environmental conditions in places of phytosociological studies. For patches of selected communities average values of slope of mountainsides and total sunlight exposure were calculated, whereas, in case of remaining environmental factors, their dominant feature was assumed.

4. Results and discussion

4.1. Phytosociological research

On the basis of the phytosociological analysis, the communities of researched meadows and pastures were classified into *Molinio-Arrhenatherete* class, and two orders: *Molinietalia* i *Arrhenatheretalia*. In many regions of Poland the communities of this class belong to the most important plant formations [12], and they are also a vital element of agricultural landscape of the Sudety [20, 21].

Within the *Molinietalia* order one group of *Angelico-Cirsietum oleracei* was distinguished (Tab. 1). It belongs to humid eutrophic meadows widespread in lowland and mountainous vegetation zones. It is a community which is highly anthropogenic, which is created and maintained solely as a result of mowing, which is a result of traditional meadow economy [12]. The community was distinguished based on the dominance of *Cirsium oleraceum* (O=3, D=767), on a used hay meadow. On one of the patches of the community there were observed species characteristic for *Calthion* and the group of *Molinietalia*. Among those species, the highest degree of constancy and frequency of occurrence was exhibited by *Juncus effusus* (O=3, D=350) and *Equisetum palustre* (O=3, D=1750) as well as *Sanguisorba officinalis* (O=3, D=633). In the community there are numerous species characteristic for *Molinio-Arrhenatheretea* class, among them the highest cover index was reached by *Holcus lanatus* (D=2000).

Within the *Arrhenatheretalia* group, lowland and mountainous anthropogenic communities of grasslands, developed on fertile, not severely humid mineral soils [12], three groups were distinguished: *Arrhenatheretum elatioris* group, *Lolio-Cynosuretum* group and *Festuco-Cynosuretum* group, as well as three communities with a dominant species: *Poa pratensis-Festuca rubra* community, *Agrostis capillaris-Festuca rubra* community, *Trisetum flavescens* community (Tab. 1).

Arrhenatheretum elatioris groups are rich floral communities of fresh highly productive meadows located on lowlands and lower mountainous locations [12]. On the re-

searched area, this group was distinguished on extensively used way, mown and meadows – pasture, basing on the domination of *Arrhenatherum elatius* (S=IV-V, D=407-2300), as well as occurrence of other species typical for the *Arrhenatherion* connection, such as: *Galium mollugo*, *Geranium pratense, Tragopogon pratensis, Campanula patula, Crepis biennis*. The most frequent and numerous species in the green growth of this community were species from the *Arrhenatheretalia* group, i.a.: *Achillea millefolium, Dactylis glomerata, Taraxacum officinale*. In the patches of the community a considerable share of *Agrostis capillaris* was also noted, which manifests itself in high values of both the degree of constancy and cover index.

Poa pratensis-Festuca rubra community was other vegetal community distinguished within the *Arrhenatheretalia* group. This community was distinguished on grasslands used in mown and pasture way. It is an indicator of a low level of grassland husbandry [22]. The floral composition of the community is poorer when compared to the *Arrhenatheretum elatioris* [12, 23] community. The *Poa pratensis-Festuca rubra* community was distinguished basing on the domination of *Festuca rubra* (S=IV-V, D=333-750) as well as presence of *Poa pratensis* (S=I-V, D=20-688). In some of the patches a considerable share of low value grasses – *Holcus lanatus* (S=V, D=275-2250) and *Anthoxanthum odoratum* (S=II-IV, D=13-1406), was recorded. According to certain researchers [24], the domination of those species in green growth may indicate a low level of fertilization and dryness of the soil. In the patches with a big share of *Holcus lanatus* the occurrence of *Alopecurus pratensis* was noted. This species displays a high degree of constancy and cover index – S=I-V, D=20-688. What is more, it occurred most numerously and most frequently among grasses*: Agrostis capillaris, Dactylis glomerata, Phleum pratense, Trisetum flavescens,* from the dicotyledon family *Trifolium repens, Taraxacum officinale, Lathyrus pratensis, Galium mollugo.* In the community, the presence of the *Carlina acauli* was noted, a species which, since 2014, is included in the list of partly protected species [14].

Another community is the community with *Agrostis capillaris-Festuca rubra*. It was distinguished based on the domination of two species: *Agrostis capillaris* (S=II-V, D=700-2750) and *Festuca rubra* (S=IV-V, D=1167-3464), on mown meadows and pasture. According to Grynia and Kryszak [20], as well as Paszkiewicz-Jasińska and Nadolna [21] the community is located on poor floristically and not sufficiently fertilized *Arrhenatherion* meadows, which is indicated by occurrence of species proper for the group.

Those species represent a diverse degree of constancy and cover index. Numerous and frequent are also species characteristic for *Arrhenatheretalia* group and *Molinio-Arrhenatheretea* class. Moreover, in the researched community a partly protected species, *Carlina acauli*, was also noted.

Another community which was qualified to the *Arrhenatheretalia* group was *Trisetum flavescens* community of the *Polygono-Trisetion* connection*,* used for hay and pasture purposes. The community was distinguished basing on the occurrence of species characteristic for the analysed line – *Trisetum flavescens* (S=IV, D=1125), as well as *Polygono-Trisetion – Alchemilla monticola* (S=V, D=456) and *Geranium sylvaticum* (S=I, D=6) connections. Species listed as representative for mountanious polygono-trisetion meadows occurred in the patch of the community[25]. Among the aforementioned species a high degree of constancy and cover index was noticed in case of *Agrostis capillaris* (S=IV, D=594), *Festuca rubra* (S=V, D=1538) and *Chaerophyllum hirsutum* (S=IV, D=275). A small share of species typical for *Arrhenatherion* may indicate a temporary nature of the community, which is indicated by the phytosociological research led in the Sudety [21].

Lolio-Cynosuretum is another community. Formation of this community is connected mainly with its pasture use. That is why, according to Grynia [26], ceasing of its pasture use may lead to its transformation into a different phytosociological unit. The *Lolio-Cynosuretum* community forms low grasses on lowlands and lower mountainous locations, which are found on wet-ground forest habitats [12]. On the researched area the community was found on pastures and on a hay-pasture meadow, it was distinguished based on the presence of *Lolium perenne* in all patches; the species showed a diverse degree of constancy and cover index (S=I-V, D=10-3542). Moreover, a high share of species typical for this community was noted, such as: *Trifolium repens* (S=IV-V, D=488-3875), *Leontodon autumnalis* (S=IV-V, D=4-500), *Cynosurus cristatus* (S=I-III, D=4-800), and a lower share of *Bellis perennis* (S=I-IV, D=5-38). Numerous species typical for *Arrhenatheretalia* group and *Molinio-Arrhenatheretea* class. Among them, the most common in all patches were *Dactylis glomerata* and *Phleum pratense.* Occurrence of those species may indicate using reseeding, as well as good habitat conditions considerably favouring their occurrence [27].

Festuco-Cynosuretum is a community with a pasture character, just like the aforementioned community. It occurs in beechwood habitats of the lower wooded section. According to Matuszkiewicz [12] it presents a more considerable floral diversity than *Lolio-Cynosuretum* community, which is confirmed by own research. *Festuco-Cynosuretum* community in the researched area was distinguished on pasture grasslands basing on the occurrence of species typical for the analysed communities and *Cynosurion* group: *Alchemilla monticola* (S=I-V, D=140-857), *Euphrasia rostkoviana* (S=II-III, D=13-30), *Carum carvi* (S=III, D=93), *Cynosurus cristatus* (S=II-V, D=150-721) and *Leontodon autumnalis* (S=IV-V, D=120-1250) and the domination of *Festuca rubra*. In all patches of the community the species reached the highest degree of constancy (S=V) and diverse cover index (D=543-1750). In all patches of the community there was a dense occurrence of *Trifolium repens* (S=IV-V, D=364-2750). Similarly as in the aforementioned community, numerous species typical for the *Arrhenatheretalia* group and *Molinio-Arrhenatheretea* class were noted there. Among them, the most common in all patches were *Dactylis glomerata* and *Phleum pratense*. In the green growth of the community the occurrence of *Carlina acauli* was noted, which is a species under legal protection.

Species richness of the communities distinguished in the researched area, determined based on an average number of species present in a phytosociological study, varied from 21 to 25. It was certainly influenced by the character of a given community, however, a high number of species is connected with a transitional character of the community. The communities with *Agrostis capillaris-Festuca rubra* and *Festuco-Cynosuretum* were the species of highest richness. Similar results for community with *Agrostis capillaris-Festuca rubra* were obtained in studies conducted in the Wałbrzych County by Paszkiewicz – Jasińska and Nadolna [22].

Table 1. Synthetic phytosociological table of the selected meadow and pasture communities
Tab. 1. Syntetyczna tabela fitosocjologiczna dla wyróżnionych zbiorowisk łąkowo-pastwiskowych

Syntaxonomic unit	***Angelico-Cirsietum oleracei***		***Arrhenatheretum elatioris***		**Community *Poa pratensis-Festuca rubra***		**Community with *Agrostis capillaris-Festuca rubra***		**Community with *Trisetum flavescens***		***Lolio-Cynosuretum***		***Festuco-Cynosuretum***	
Number of relevés	3		23		47		43		10		70		25	
	O	D	S	D	S	D	S	D	S	D	S	D	S	D
ChAss. *Angelico-Cirsietum oleracei*														
Cirsium oleraceum	3	767			I-II	17-90	I-IV	33-46			I	55		
ChAss. *Arrhenatheretum elatioris*														
Arrhenatherum elatius			IV-V	407-2300	I-V	6-388	I-V	10-607	I	13	I-II	50-110		
Geranium pratense			II	60	I-II	17-50					II-15			
D. com. *Poa pratensis - Festuca rubra*														
Poa pratensis	2	333	II-III	175-450	I-V	20-688	I-IV	46-210	III	375	I-V	25-1938	II-V	200-436
Festuca rubra			III-V	236-2417	II-V	333-3750	IV-V	1167-3464	V	1538	I-V	8-1519	V	543-1750
Alopecurus pratensis					II-V	120-1680	I-III	7-710	III	881	III-V	860-1458	I-V	100-656
Holcus lanatus	3	2000	V	436-1333	V	275-2250	I-V	10-425			I-V	8-750	V	500
D. com. with *Agrostis capillaris-Festuca rubra*														
Agrostis capillaris			IV-V	375-2417	II-V	125-1938	II-V	700-2750	IV	594	I-V	83-4625	III-V	250-2000
D. com. with *Trisetum flavescens*														
Trisetum flavescens			I-IV	92-407	II-V	125-1183	I-III	100-450	IV	1125	I-V	10-410	I	30
ChAss. *Lolio - Cynosuretum*														
Trifolium repens			I-V	8-2536	IV-V	200-2750	III-V	183-1300	V	506	IV-V	488-3875	IV-V	364-2750
Lolium perenne					III-IV	25-300	I	10			I-V	10-3542	II	20
Leontodon autumnalis					I-III	8-583	I-V	71-1650	I	69	III - V	25-500	IV-V	120-1250
Bellis perennis					II	13					I-IV	5-38		
ChAss. *Festuco - Cynosuretum*														
Alchemilla monticola	2	183	I	10-83	III-V	25-767	I-IV	10-900	V	456	I-V	4-200	I-V	140-857
Euphrasia rostkoviana					II	13	I	71			I	4-6	II-III	13-30
Colchicum autumnale							V	140			III	25		
Carum carvi					I-III	150-194			I	13	II	92	III	93
ChAll. *Calthion*														
Juncus effusus	3	350												
Myosotis palustris	2	183												
Scirpus sylvaticus	1	167									III	250		
Geum rivale	1	17									II	13		
Juncus conglomeratus	3	350			II	13	I	10			I	4-5		
Cirsum rivulare					III	25	I	4			I	6-8		

Syntaxonomic unit	*Angelico - Cirsietum oleracei*		*Arrhenatheretum elatioris*		**Community** *Poa pratensis - Festuca rubra*		**Community with** *Agrostis capillaris - Festuca rubra*		**Community with** *Trisetum flavescens*		*Lolio-Cynosuretum*		*Festuco-Cynosuretum*	
Number of relevés	3		23		47		43		10		70		25	
ChAll. *Molinion*														
Pimpinella saxifraga			V	192			I-V	10-258			I-IV	8-33	I-V	7-320
Briza media							I	4					II	110
Potentilla erecta											II	17-167	I	100
ChAll. *Filipendulion*														
Filipendula ulmaria	2	33					I	4						
ChAll. *Arrhenatherion*														
Campanula patula			I-V	5-307	I-III	6-110	I-V	10-200	II	25	I-IV	10-33	I-III	6-110
Galium mollugo			I-V	55-1750	I-V	6-1750	I-V	8-229	I	63	I-V	10-425	II	60
Crepis biennis			III-V	75-293	II-III	20-200	II-III	17-200			I-V	10-312	III	81
Knautia arvensis			II	110	I-IV	38-63	II-IV	17-164			I-V	8-42	II	110
Tragopogon pratensis			I-V	5-117	I-IV	10-150	I	4-10			I-II	4-69	II	13
ChAll. *Polygono-Trisetion*														
Geranium sylvaticum					II	69			I	6			III	157
ChAll. *Cynosurion*														
Cynosurus cristatus			I-II	14-50	I-IV	10-356	I	42	III	319	I-III	4-800	II-V	150-721
ChO. *Molinietalia*														
Equisetum palustre	3	1750												
Sanguisorba officinalis	3	633			I	130	II-V	20-767						
Lotus uliginosus	1	197												
Lychnis flos-cuculi	1	17			I-II	6-130	II	50					I	30
Angelica sylvestris	1	17	II	14	I	140	I-II	10-17	V	394				
Deschampsia caespitosa					I-IV	6-190	II-IV	17-220	II	25	II-V	13-1125	II-V	13-310
ChO. *Arrhenatheretalia*														
Achillea millefolium			II-V	86-1035	II-V	17-263	III-V	33-410	IV	100	III-V	70-913	III-V	29-330
Dactylis glomerata			IV-V	50-910	III-V	138-1667	I-V	10-910	V	1250	II-50	50-1225	IV-V	220-907
Lotus corniculatus			I	8	I-III	6-390	II-IV	14-470	I	13	I-V	13-275	III	180
Heracleum sphondylium			I-III	7-160	II-V	13-381	I-IV	10-183	II	25	II-V	15-350	I-V	30-381
Leucanthemum vulgare			I-II	20-83	I-II	6-17	III-IV	25-108			I-III	8-100	I-II	6-20
Taraxacum officinale			I-V	17-676	II-V	13-1150	II-V	40-1160	V	563	III-V	25-3250	I-V	100-656
Trifolium dubium			II	14	II-IV	13-250	I-III	4-300			I-IV	4-310	II-V	69-240
Daucus carota			III	70	I	6	I	10			II-V	12-267		
Pimpinella major			II-III	15-86	I-II	20-110	II	17-167			II-III	12-175		
ChCl. *Molinio-Arrhenatheretea*														
Alopecurus pratensis					I-V	20-1850	I-IV	10-467	II	250	I-V	4-1005	I-V	100-1600

Syntaxonomic unit	*Angelico-Cirsietum oleracei*		*Arrhenatheretum elatioris*		Community *Poa pratensis-Festuca rubra*		Community with *Agrostis capillaris-Festuca rubra*		Community with *Trisetum flavescens*		*Lolio-Cynosuretum*		*Festuco-Cynosuretum*	
Number of relevés	3		23		47		43		10		70		25	
Festuca pratensis	3	917	I-V	83-786	I-IV	6-40	I	7	III	38				
Rhinanthus minor			IV	36	III-V	230-410	II-V	20-500	V	719	I-V	8-1125	IV-V	310-600
Ranunculus acris	3	350	I	5-8	II-V	13-1470	I-V	8-917	IV	213	I-V	4-275	III-IV	164-270
Lathyrus pratensis	3	200	I-II	8-65	III-V	25-500	I-V	100-371	V	344	I-V	6-165	III-V	25-390
Rumex acetosa	3	200	II-V	15-192	IV-V	190-500	II-V	14-617	IV	269	I-V	13-296	III-V	29-850
Plantago lanceolata	2	183	I	8-71	II-IV	33-80	I-V	20-350			I	4-8	I	30
Centaurea jacea			I	71	I-V	25-913	I-IV	7-1583			I-V	8-320	I-V	6-330
Trifolium pratense			II-IV	17-155			I	4-83	V	663	I	4-38		
Avenula pubescens					II-V	17-1875	II-V	120-650	III	356	II-V	20-1969	IV-V	400-614
Phleum pratense	3	500	II-V	17-1429							I	4		
Leontodon hispidus					II	17	I-III	10-100			I-V	4-50	I	30-100
Prunella vulgaris					IV	475			I	63	I-III	100-800	IV	475
Poa trivialis			II	143	I-V	6-267	I-IV	10-436	V	450	I-IV	8-183	I-IV	6-229
Vicia cracca			I-III	83-160							I-II	38-129		
Agrostis gigantea			V	543	III	138					I	100		
Bromus hordeaceus														
ChO. *Nardetalia*							I	4					III	210
Nardus stricta														
ChCl. *Nardo-Callunetea*							I-II	8-154			I-II	4-17	I-II	30-200
Hieracium pilosella L.					II-IV	17-256	I-IV	7-40			I	4-46		
Luzula campestris (L.) DC.			IV	108										
Towarzyszące i chronione					II-IV	13-1406	I-V	8-320			I-II	5-296	IV	130-210
Anthoxanthum odoratum			III-IV	33-86					I	13				
Cirsium helenioides									IV	275	I	4	V	307
Chaerophyllum hirsutum							II-III	13-30			I	8	I	10
Carlina acaulis			I	10									I	10
Mean number of species in a relevé	22		21		21		25		24		21		25	

Source: own studies / *Źródło*: opracowanie własne

S – degree of constancy (min.-max.): I – species existing in 1-20% of phytosociological affiliation; II – species existing in 21-40% of phytosociological affiliation; III – species existing in 41-60% of phytosociological affiliation; IV – species existing in 61-80% of phytosociological affiliation; V – species existing in 81-100% of phytosociological affiliation,
O – frequency of occurrense,
D – cover index (min.-max).

4.2. Cartographic research

Angelico-Cirsietum oleracei community was located in the Nowa Ruda Area (Central Sudety), on the slopes with east exposure and the average slope of 2.9°, on the altitude of 480 m.a.s.l and the value of the total sunlight exposure reaching 104%. In the surface layer of this community there are podzols and silt loam.

Arrhenatherum elatioris community was distinguished on slopes. The dominant azimuth of the slopes is north-east, east, south-west and west. The average value of slope and sunlight amounted to, respectively, 6.4° and 110% and the height interval amounted to 430-480 m.a.s.l. The community was formed on brown earth, silt loam and medium silt clay.

Community with *Trisetum flavescens* was located in the Złote Mountains (East Sudety), on the slopes with a north-west exposure and average slope of 9.9°, in the height interval of 580-590 m.a.s.l. and the total sunlight value reaching 105%. In the surface layer of this community there are brown earth and medium silt clay.

Table 2. Environmental characteristics of selected meadow and pasture communities
Tab. 2. Charakterystyka przyrodnicza wyróżnionych zbiorowisk łąkowo-pastwiskowych

Phytosociological unit	***Angelico-Cirsietum oleracei***	***Arrhenatheretum elatioris***	**Community *Poa pratensis-Festuca rubra***	**Community with *Agrostis capillaris-Festuca rubra***	**Community with *Trisetum flavescens***	***Lolio-Cynosuretum***	***Festuco-Cynosuretum***
Location (macroregion,mesoregion)	Central Sudety: Nowa Ruda Area	Central Sudety: Bardo Mountains, Bystrzyca Mountains	Central Sudety: Nowa Ruda Area, Ścinawa Area, Kłodzko Valley East Sudety: Śnieżnik Massif, Złote Mountains	Central Sudety: Kłodzko Valley, Orlica Piedmont, Stołowe Mountains, Bardo Mountains East Sudety: Śnieżnik Massif, Złote Mountains	East Sudety: Złote Mountains	Central Sudety: Kłodzko Valley, Nowa Ruda Area Ścinawa Area, Orlica Piedmont, Stołowe Mountains, Bardo Mountains East Sudety: Śnieżnik Massif	Central Sudety: Kłodzko Valley East Sudety: Śnieżnik Massif, Złote Mountains
Altitude [m.a.s.l.]	480	430 – 480	430 – 480, 800 - 840	450 – 540, 720, 800 - 810	580 - 590	400 – 500, 690	520 – 590, 720
Prevailing soil types	podzol, silt loam	brown earth; silt loam, moderately silty loam.	podzol, brown earth; light clay and moderately silty loam, silt loam.	podzol, brown earth; light clay including silty loam.	brown earth; moderate silty loam.	podzol, brown earth; moderately silty loam, light silty loam, silt loam.	brown earth; moderately silty loam.
Soil classification	Ł IV	Ł IV, Ps IV	Ps IV–VI, Ł IV	Ps IV, Ps V, Ł V	Ł IV	Ł III, Ł IV, Ps IV-VI	Ps IV, Ps V
Dominant exposure	E	E/NE, S/SW, W	NE, SW	SW, NE	NW	SW, NW	W/SW
Average slope	2.9	6.4	8.4	7.4	9.9	6.6	6.1
Average potential sunlight exposure	106	110	109	105	106	107	104

Source: own studies / *Źródło*: opracowanie własne

E – south, E/NE – south, north-east, S/SW – south, south-east, W – west, NE – north-east, SW – south-west, NW – north-west, W/SW – west, south-west

The dominant azimuth of the slopes of the *Poa pratensis-Festuca rubra* Community is north-east and south-west. The average slope and sunlight exposure amounted to, respectively, 8.4° and 106%. The community was located on two height intervals: 430-480 m.a.s.l. and 800-840 m.a.s.l. The most common type of soil was podzols and brown earth, while the most common kind was light clay and medium silt clay.

Community with *Agrostis capillaris-Festuca rubra* was formed mostly in the south-west, in case of one of the patches north-east slopes. Average slope is 7.4° and with the height intervals amounting to 450-540 m.a.s.l., 710-720 m.a.s.l. and 800-810 m.a.s.l. The value of total sunlight exposure amounted to 107%. The dominant type of soil was podzol and brown earth, while the prevailing kind was light clay including silt clay.

Lolio-Cynosuretum community was created on the south-west and north-west slopes with an average slope of 6.6°, with the height interval of 400-500 m.a.s.l. and average value of total sunlight amounting to 106%. In case of one of the patches its average value reached 690 m.a.s.l. The community was formed on podzol and brown earth, as well as medium and light slit clay and slit loam.

*Festuco-Cynesur*owisko community was formed on slopes with west and south-west exposure, with average slope amounting to 6.1°, in the height interval between 520-590 m.a.s.l. and the average value of total sunlight amounting to 109%, on brown earth and medium slit clay. In case of one patch its average height amounted to 720 m.a.s.l. The community was formed on podzol and medium silt clay.

According to the conducted analysis of cartographic data, the distinguished communities are located mainly on slopes with high average values of slopes (above 6°), on poorly permeable soils with a high share of silt fraction in the granulometric composition. They are composed mainly of silt loam, as well as light and medium clay, also with silt features. According to Kostuch [5] silt fraction is conducive to greater species richness. The dominant type of soils is proper brown earth as well as podzol. According to Matuszkiewicz [12], lowland and mountainous anthropogenic grassland communities develop on fertile and very humid mineral soils. The average slope, as well as averaged values of sunlight exposure, indicates a moderately warm character of positions of distinguished communities. It is

also confirmed by other authors who pinpoint the moderate thermophilic character of grasslands in the mountains [23, 28].

5. Conclusion

1. Grassland communities distinguished on the researched area located in the Kłodzko County belong to *Molinio-Arrhenatheretea* class and *Molinietalia* and *Arrhenatheretalia* group. The most numerous are communities from the *Arrhenatheretalia* group of lowland and mountainous anthropogenic communities of grassland developed on fertile and moderately humid mineral soils.
2. The distinguished meadow and pasture communities were formed mainly on the mountainsides with a considerable slope (above 6°) and with a diverse exposure, on soils with a big share of silt fraction in their granulometric composition.
3. The average value of total sunlight for the slopes is higher than average, which points to the thermophilic tendency of the distinguished communities.
4. The largest number of species in a phytosociological study was present in community with *Agrostis capillaris-Festuca rubra* and *Festuco-Cynosuretum*. The communities were formed on the mountainsides mostly "warm" – south-west and west, with slope from 6 to 7° and with the sunlight exposure value from 107 to 109.

6. References

[1] Howard J. A., Mitchell C.W.: Phytogeomorphology, New York, Wiley, 1985, 222 pp.
[2] Kaspar, T.C, Colvin, T.S., Jaynes, B., Karlen, D.L., James, D.E, Meek, D.W.: Relationship between six years of corn yields and terrain attributes, Precision 2003, Agriculture, 4, 87-101.: http://naldc.nal.usda.gov/download/8423/PDF.
[3] Menghi M., Cabido M., Peco B., Pineda F. D.: Grassland Heterogeneity in Relation to Lithology and Geomorphology in the Córdoba Mountains, Argentina, Vegetatio, vol. 84, nr 2, 1989, 133-142.
[4] Hryncewicz Z., Borkowski J.: Fitosocjologiczne i gleboznawcze kryteria ustalenia sposobu użytkowania ziemi w Sudetach. Problemy Zagospodarowania Ziem Górskich PAN. Z. , 1977, 18, 73-93.
[5] Kostuch R.: Przyczyny występowania różnorodności florystycznej ekosystemów trawiastych. Annales UMCS. Sectio E. Suppl. L, 1995, 23-32.
[6] Kondracki J.: Geografia fizyczna Polski, Wyd. Nauk. PWN, Warszawa 2000, 468 pp.
[7] Schmuck A.: Rejonizacja pluwiotermiczna Dolnego Śląska. Zeszyty Naukowe WSR Wrocław. T. 5. Melioracja. Nr 27, 1960, 1-15.
[8] Spis rolny 2010 r.: http://www.stat.gov.pl/bdl/app/dane_cechter.dims?p_id=369893&p_ token= 419949581#.
[9] Nadolna L., Żyszkowska M.: Characteristics of grassland in the Polish Sudetes in view of fodder production potential and grassland protection. Journal of Water and Land Development, 2011, 15, 29-40.
[10] Pawłowski B.: Skład i budowa zbiorowisk roślinnych oraz metody ich badania, [w:] Szata roślinna Polski. T. 1, red. W. Szafer, K. Zarzycki, PWN, Warszawa 1972, 237-269.
[11] Tichỳ L.: Juice, software for vegetation classification, Journal of Vegetation Scence 2002, 13, 451-453.
[12] Matuszkiewicz W.: Przewodnik do oznaczania zbiorowisk roślinnych Polski, Wyd. Nauk. PWN, Warszawa 2007, 537 pp.
[13] Mirek Z., Piękoś-Mirkowa H., Zając M.: Flowering plants and Pteridophytes of Poland - a checklist - W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków 2002, 442 pp.
[14] Rozporządzenie Ministra Środowiska z dnia 9 października 2014 r. w sprawie ochrony gatunkowej roślin, Dz.U. 2014, poz. 1409.
[15] Mapa ewidencji gruntów i budynków powiatu kłodzkiego, Geodeta powiatu kłodzkiego, wersja elektroniczna, opis atrybutowy: bonitacja i numery działek, Kłodzko 2009.
[16] Mapa topograficzna układu 1965, skala 1:10 000, GUGiK, Warszawa 1989 r. (wersja elektroniczna).
[17] Hutchinson M.F.: A new procedure for gridding elevation and stream line data with automatic removal of spurious pits, Journal of Hydrology 1989, 106, 211-232.
[18] Mapy glebowo-rolnicze powiatu kłodzkiego w skali 1:5000 (cięcie arkuszowo-obrębowe),Wojewódzkie Biuro Geodezji i Terenów Rolnych, Wrocław 1973.
[19] Štružka V.: Metody badań bioklimatycznych, Przegląd zagranicznej literatury geograficznej, Zagadnienia klimatologii 3, Warszawa 1959, 170-195.
[20] Grynia M., Kryszak A.: Ocena geobotaniczna zbiorowisk łąkowych Obniżenia Dusznickiego oraz Gór Bystrzyckich, Zeszyty Problemowe Postępów Nauk Rolniczych 1996, 442, 97-104.
[21] Paszkiewicz-Jasińska A., Nadolna L.: Zbiorowiska łąkowe w powiecie wałbrzyskim - możliwości ich ochrony w ramach pakietów przyrodniczych programu rolnośrodowiskowego, Woda Środowisko Obszary Wiejskie 2013, 13, 1(41), 115-128.
[22] Kutyna I., Neczkowska M.: Zbiorowiska seminaturalne z rzędu *Arrhenatheretalia*, klasy *Molinio-Arrhenatheretea* występujące na terenie byłej Akademii Rolniczej w Szczecinie przy ulicach J. Słowackiego i Papieża Pawła VI. Folia Pomeranae Universitatis Technologiae Stetinensis. Argicultura, Alimentaria, Piscaria et Zootechnica, 2009, Nr 271 (10), 87-96.
[23] Nadolna L.: Wartości przyrodnicze sudeckich użytków zielonych o zróżnicowanym sposobie użytkowania na tle warunków siedliskowych i fizjograficznych, Woda Środowisko Obszary Wiejskie 2012, 10, 4(32), 307-318.
[24] Stosik T., Krasicka-Korczyńska E.: Łąki „Linice" w Borach Tucholskich – historia, struktura fitocenoz i zagrożenia. Ekologia i Technika. Nr 20(4), 2012, 217-226.
[25] Perzanowska J., Świerkosz K., Mróz W.: Górskie łąki konietlicowe użytkowane ekstensywnie (*Polygono-Trisetion*). W: Murawy, łąki, ziołorośla, wrzosowiska, zarośla. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. T. 3. Pr. zbior. Red. J. Herbach. Warszawa, 2004, MŚ, 212-219.
[26] Grynia M.: Kierunki zmian szaty roślinnej zbiorowisk łąkowych w Wielkopolsce. Rocz. AR w Pozn., 284, Roln. 47, 1996, 15-27.
[27] Kryszak A.: Różnorodność florystyczna zespołów łąk i pastwisk klasy Molinio-Arrhenatheretea R.Tx.1937 w Wielkopolsce w aspekcie ich wartości gospodarczej. Roczniki AR Poznań, 2001, Rozprawy Naukowe z. 314, 182 pp.
[28] Kostuch R.: Przyrodnicze podstawy gospodarki łąkowo-pastwiskowej w górach, PWRiL, Warszawa 1976, 151pp.