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The succession of abandoned glades and its impact on the diversity of flora in Beskid Mały Mountains (Southern Poland)

Introduction

For hundreds of years, pasturage was the most optimal way of maintaining pasture plant communities. The animal species bred on pastures in Beskidy Mountains, which included sheep, goats, cows, and oxen. In the 18th century, when shepherding was at its peak, tens of thousands of cattle were kept and bred in the Beskidy Mountains. The primeval beech and fir forest provided feed for animals during summer and winter as well as wood for fuel and for construction of pens, huts, and houses. The animals that grazed on the pastures naturally mowed the plants and fertilised the soil, and, at the same time, they provided a livelihood to the shepherds. The shepherding industry that developed was based on products made from ewe's milk, meat, wool, leather, and it constituted the backbone for the development of local economies and local communities. In the shepherding huts, butter and cheeses were produced – both soft cheeses such as 'bundz' and 'bryndza' as well as hard cheeses such as 'oscypek' (Leszczyński, 1932; Pawłowska, 1965; Gołek et al., 2015).

In the second half of 19th century, the shepherding industry began to decline. The shepherds, who depended on primeval forest as a source of feed for their animals, started to feel the effects of the industrial revolution. The forest owners began to cut down trees for construction materials. Spruce trees were planted in place of primeval forest tree species, which grew much faster but could not be used as feed for the animals (Pawłowska, 1965). On top of that, more and more pastures were converted into farm fields, and the farmers also began to set up their farms at higher altitudes in the mountains. Shepherding experienced its greatest decline at the beginning of 20th century. It slightly rebounded after the First World War; however, as a result of fast economic changes in the countryside, the era of extensive shepherding came to an end at that time (Kufa, 2005; Gołek et al., 2015).

Poland economic transformation, which took place in 1980s and 1990s, took a heavy toll on the Polish farming industry as whole. Due to drops in prices of agricultural products, the profitability of farming activities significantly declined during that time. For example, in south-eastern Poland, the sheep population declined by 86% between 1987 and 1996. In addition, during those years, production shifted from state-owned enterprises into the private sector (Cach-Czaja, 1998). At that time, many Polish farmers reduced the pasture areas by either fallowing them or turning them into farm fields to produce crops mostly for their own needs (Ostromęcki, Piechota, 1996). The abandonment of pastures and the discontinuation of mowing and grazing by animals resulted in the gradual degradation of meadows and pastures, which began to accumulate the overgrown plant matter and dead plant remains (Kornaś, 1990). Additionally, such fallowed pastures experienced uncontrolled growth of pasture weeds as *Rumex alpinus*, *Juncus* sp., leading to reduction and, ultimately, complete disappearance of plants for grazing and valuable plant species (Gołek et al., 2015).

The aim of this paper is to prove that cessation of grazing, mowing, and other usable treatments on mountain glades in the Beskid Mały Mountain range results in the reduction of floristic diversity of meadows and pasture areas.

Study area

The studied area includes the mountain massif of Łamana Skała (929 m.a.s.l.) – 49°45′49.0″N; 19°23′45.7″E and Leskowiec (918 m.a.s.l.) – 49°47′19.0″N; 19°26′36.4″E, in Beskid Mały (Southern Poland). The Łamana Skała Group is a part of the Beskid Mały Mountain range, positioned in its central part. It is located to the east from the Kocierz Group, ranging from the Beskidek Pass to the Skawa River valley, and includes the Leskowiec massif (Truś, 2008). According to physiogeographic regionalisation by Kondracki (2011), this area belongs to the Beskidy Zachodnie (Western Beskidy) Macroregion, and the Beskid Mały Mezoregion. According to geobotanical division of Poland by W. Szafer, the studied area belongs to Zachodnio-Karpacki (Western Carpathian) Section, the Beskidy Region, and the Śląsko-Babiogórski Sub-region (Szafer, Zarzycki, 1977).

In terms of landscape, the Beskid Mały is a group of larger and smaller mountain ranges, valleys, as well as a number of saddles and passes. It spans two altitudinal zones – the flysch-plateau zone (pogórze fliszowe) (300–600 m.a.s.l.) and the mixed-forest zone (regiel dolny) (600–1150 m.a.s.l.). The hillsides, especially on the northern side of the range, are quite steep (between 15° and 30°), while crests and peaks are rather flat. The mountains are being shaped by various erosion processes, including flysch landslides, wearing down by water, washout of farm fields, ero-

sion attributable to changes in temperature, etc. The area consists in 90% of hard sandstone and shale (łupki godulskie) of medium and lower levels, which formed during Lower Cretaceous epoch. Numerous valleys are covered by brown earth (mostly clays), which, in combination with large number of springs, creeks, and rivers, is conducive to agriculture (Ziemońska, 1973; Matuszczyk, 1981). Besides brown soils (which represent approx. 90% of soils), the Beskid Mały also has podsolic soils (approx. 5%), rusty soils, and aerosols. The area also features alluvial soils, delluvial soils, luvisolic soils, pseudo-gley soils, and gley soils (*Forest Management Plan…*2006/2015).

According to division by M. Hess (1965), the studied area spans two horizontal mountainous vegetation regions, corresponding to the following two altitudinal zones: the flysch-plateau zone (250–600 m.a.s.l.), with an average annual temperature of +8°C, a total annual precipitation of 800 mm, and a vegetation period length of 220 days, and the mixed-forest zone (600–1100 m.a.s.l.), with an average annual temperature of +4°C, a total annual precipitation of 1400 mm, and a vegetation period length of 170 days. Such areas experience frequent and very strong winds, especially in early spring and autumn, the intensity of which is increasing with altitude.

Methods

Studies were conducted from January to October 2015 and from May to July 2016. 54 squares (plots) with area of 25 m^2 each (5×5 m) were randomly designated on southern slopes of Leskowiec and Łamana Skała massif in the Beskid Mały. The following information was recorded for each plot: the name of the township/glade, geographic coordinates, altitude in meters above sea level, and the date and time of conducting the floristic survey. Geographic coordinates for the plots were taken from a GPS device and verified with use of a tourist map of *Beskid Mały in the scale of 1:50000* (2014). Altitude in meters above sea level was read from the 'Altimeter' application and verified with the aforementioned tourist map (Appendix 1 – Tab. 1).

To determine the botanic composition of each plot, the Klapp (1965) estimation method was used. This method was used to determine the percentage share of species in each plot with accuracy of about 1%. All the species that were identified in the given plot were recorded in the following sequence: grasses, legumes, other herb species, as well as trees and shrubs. The share of individual species within the group was estimated, starting with the most commonly occurring ones. The species whose share was less than 1% were assigned with the '+' sign. The samples of species, which were not identified directly in the field, were collected and then identified in the laboratory of the Department of Botany, the Institute of Biology of the Pedagogical University of Kraków. During field work, particular attention was paid to differences between the

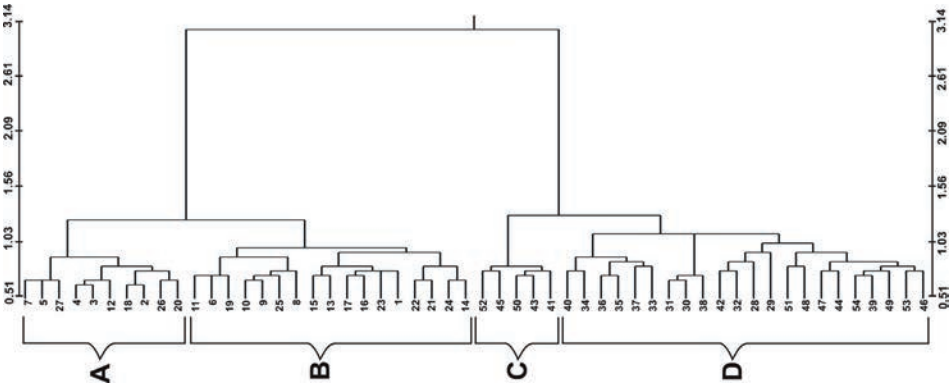

Fig. 1. Classification of the studied plots based on the percentage coverage of species; A – pasture with *Nardus stricta*; B – hay-meadow; C – unused plots with *Pteridium aquilinum*; D – unused plots with shrubs

glades that were used and those which were unused. Areas located directly beneath power lines as well as areas transformed by human activities or defaced by animals, e.g., by boars were not included in the research. Bogs and waterlogged meadows and glades on which activities are conducted only partially, e.g., where self-planted trees or shrubs are cut down and removed, were also excluded from the research.

The floristic data from all the analysed plots were entered in the TURBOVEG database, and then they were subjected to hierarchical numerical classification (Gauch, 2012) based on the percentage coverage of species. Classification was performed with use of MULVA-5 software package (Wildi, Orlóci, 1996). Similarities among plots were calculated according to van der Maarel's formula, and then the plots were grouped using the Ward's method (Minimum Variance Clustering). This method uses the variance analysis approach to estimate distance between cluster centres (Dzwonko, 2007). In the obtained dendrogram, the groups of plots, which had the same quantitative coverage of species, were separated.

For the individual groups of plots, weighted average values of Ellenberg indicator values were calculated, based on percentage coverage by species, for light (L), moisture (F), soil pH (R), and nitrogen content in soil (N) (Ellenberg et al., 1992). In addition, Shannon-Weaver general diversity indicators (H) (Shannon-Weaver, 1963), Pielou uniformity indicators (J) (Pielou, 1975), and dominance indicators (C) (Simpson, 1949; Shannon, Weaver, 1963) were compared. For biodiversity indicators, after Levene's previous test, the statistical significances between the groups were determined using the Kruskal-Wallis nonparametric test (for H and J) and the one-way ANOVA parametric test ($p < 0.05$).

Plant names according to Mirek et al. (2002).

Results

Hierarchical numerical classification, which was performed on the basis of percentage species coverage in the plots, yielded the following four utility-floristic groups: A – pasture with *Nardus stricta*, B – hay-meadow, C – unused plots with *Pteridium aquilinum*, and D – unused plots with shrubs (Fig. 1). The floristic characteristics and the quantitative share of species in the aforementioned groups are shown in tables 2–5 (Appendix 1).

The first two groups distinguished on the study area were A – pasture with *Nardus stricta,* and B – hay-meadow, which include the glades on which grazing, mowing and other usable treatments are still conducted. They have a higher average number of species in the plots – ranging from 21 to 22 (Tab. 6). They are dominated by grasses such as *Festuca rubra* and *Poa trivialis* (Appendix 1 – Tab. 2–3). The other two groups of plots (C and D) are unused glades. The highest total number of species was recorded in unused plots with shrubs D – 69, and the lowest was recorded in unused plots with *Pteridium aquilinum* C (Fig. 2).

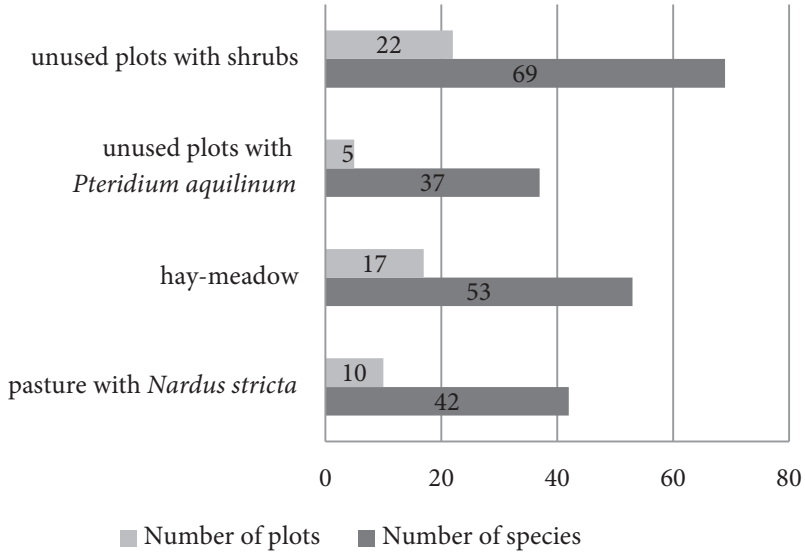

Fig. 2. Total number of species in floristic tables (Appendix 1 – Tab. 2–5) of the distinguished groups of plots

The comparison of diversity, uniformity, and dominance indicators (Tab. 6) has shown that the highest value of the (H) indicator was recorded in pasture with *Nardus stricta*, and the lowest was recorded in unused plots with *Pteridium aquilinum*. The greatest uniformity was recorded in unused plots with shrubs and

pasture with *Nardus stricta*, and the smallest in unused plots with *Pteridium aquilinum*. The highest dominance indicator was recorded in unused plots with *Pteridium aquilinum* and in unused plots with shrubs, the lowest in multi-species plots of hay-meadow.

Tab. 6. Average values of Shannon-Weaver general diversity indicators – H, uniformity – J and dominance – C, calculated for groups of plots distinguished on studied glades of Beskid Mały; in column for H and J no statistical significance with Kruskal-Wallis test, $p < 0.05$; for C – a, b statistical significance with Tukey test, $p < 0.05$

Group name of plots	Average number of species in plot ± SD	Biodiversity indicators (values and ranges)		
		H	J	C
A – pasture with *Nardus stricta*	21 ±5.37	2.69 2.48–3.04	0.91 0.79–1.07	0.07[ab] 0.03–0.17
B – hay-meadow	22 ±2.43	2.68 2.32–3.02	0.87 0.75–1.01	0.05[b] 0.04–0.09
C – unused plots with *Pteridium aquilinum*	18 ±3.27	2.46 2.09–2.81	0.86 0.74–0.97	0.11[ab] 0.06–0.14
D – unused plots with shrubs	18 ±3.94	2.62 2.07–2.86	0.91 0.78–0.99	0.11[a] 0.04–0.44

Tab. 7. Average values of Ellenberg indicators (light – L, moisture – F, soil pH – R, nitrogen content in soil – N) calculated for groups of plots distinguished on studied glades of Beskid Mały

Group name of plots	Ellenberg indicators (values and ranges)			
	L	F	R	N
A – pasture with *Nardus stricta*	7.13 6.96–7.33	5.68 5.37–6.03	5.20 4.65–6.07	5.04 4.71–5.68
B – hay-meadow	7.10 6.81–7.41	5.50 5.25–5.88	5.90 5.33–6.52	5.68 4.90–6.43
C – unused plots with *Pteridium aquilinum*	6.56 6.14–7.04	5.44 5.20–5.79	3.99 3.65–4.19	4.06 3.73–4.46
D – unused plots with shrubs	6.71 5.81–7.43	5.92 4.96–7.08	4.59 2.78–6.50	4.68 3.60–6.38

The comparison of average values of Ellenberg indicators (Tab. 7) has shown that the greatest number of photophilous species occurred in plots of pastures with *Nardus stricta*, and the smallest number of such species occurred in unused plots with *Pteridium aquilinum*. In those plots, the values of indicators for light (L) were lowest. The highest average indicator for moisture (F) was recorded in unused plots with shrubs, and the lowest was recorded in plots with *Pteridium aquilinum*. The highest average values of soil pH indicator (R) and the nitrogen content in soil (N) were recorded in hay-meadows, and the lowest values of those indicators were recorded in plots with *Pteridium aquilinum*.

Discussion

Pastures and glades in Beskidy Mountains were created artificially as a result of grazing, mowing, and other usable treatments conducted by the people who had been migrating to that area since the Middle Ages. Initially, their activities were limited to cutting down forests in valleys and at the foothills of mountain ranges, to set up farm fields. Later periods, namely 14th and 15th centuries, witnessed the wave of Vlach migrations that came from Romania along the Carpathian arc. They began to cut down forests at higher altitudes to make space for pastures, some of which were still used as recently as the beginning of the 20th century. Extensive pasturage activities resulted in the emergence of diverse plant communities, which are categorised as semi-natural (Pelc, 1958; Pawłowska, 1965). They were dominated by domestic species that needed a specific form of human activities, such as mowing or shepherding (Gołębiowski, 1990; Michalik, 1990). In the past, the areas covered by the botanical composition survey mostly included *Gladiolo-Agrostietum* (Br.-Bl. 1930) Pawł. et Wal. 1949 meadows at different stages of their transition towards *Anthoxantho-Agrostietum* Sillinger 1933 pastures mentioned in, among others, Czech sources – Hájek (2007) but not mentioned by Matuszkiewicz (2007), as well as poor in nutrients *Hieracio-Nardetum* Kornaś 1955 n.n. em. Balcerk. 1984 swards. The direction of the transition of those phytocoenoses depended on the manner of their usage, and the intensity of usage and maintenance activities conducted (Zwolińska, 1960; Kornaś, 1990; Rozbrojová et al., 2010; Gołek et al., 2015).

The botanical composition of one of the groups that was determined on the analysed area, referred to in this study as pasture with *Nardus stricta* – A (Appendix 1 – Tab. 2), is similar to *Hieracio-Nardetum* Kornaś 1955 n.n. em. Balcerk. 1984 sward (Matuszkiewicz, 2007), which had been said to occur in that area. The phytocoenoses of that kind usually developed in places with extensive sheep pasturage and with insufficient organic fertilisation, and this is confirmed by relatively lower values of the soil nitrogen (N) indicator among other used plots (Tab. 7). The soils, on which such plant communities emerge, are barren and poor in nutrients. They give hay of very poor quality, and they very quickly grow over when unused. Such swards serve the erosion-prevention function. *Nardus stricta* is a grass with very thin leaf-blades, whose roots and shoots are very closely packed together at the base of the plant. In the past, pastures with *Nardus stricta* were a very widespread plant community that developed on the areas with pasturage activities. Currently, they are becoming increasingly hard to come by, and they occupy small surfaces. They can still be found next to shepherds huts, in sheep-pens, and on the edges of the glades (Michalik, 1990; Rozbrojová et al., 2010; Gołek et al., 2015). Their relatively high species richness shows in the dynamic changes occurring here as a result of the cessation of traditional management (Tab. 6).

Other species identified in the plots of that type include *Potentilla anserina*, *Festuca rubra*, *Anthoxanthum odoratum,* and *Carex rostrata* (Appendix 1 – Tab. 2).

The most important plant community of the mountain glades of the mixed-forest zone in the Western Carpathians is still the *Gladiolo-Agrostietum* meadow (Kornaś, 1967; Kornaś, Medwecka-Kornaś, 1967). Until recently, this plant community dominated on almost every mountain glade. Currently, due to discontinuation of usage of the glades, the patches of typical *Gladiolo-Agrostietum* meadows are becoming increasingly rare. *Gladiolo-Agrostietum* is a plant community of hay-meadows, which better serve as a source of hay rather than a pasture. It develops on glades that are moved once or twice a year, where the grazing takes place only after mowing, and which are fertilised on regular basis by setting up sheep-pens or scattering the manure. This plant community is characterised by a large number of species, reaching more than 50 flowering plant species per 100 m^2. The dominating species include primarily grasses, including but not limited to *Agrostis capillaris*, *Dactylis glomerata*, *Arrhenatherum elatius*, *Festuca rubra,* and *Anthoxanthum odoratum*. This plant community also features perennial plants such as *Gladiolus imbricatus*, *Lychnis flos-cuculi*, *Heracleum sphondylium*, *Achillea millefolium*, *Leontodon hispidus*, *Hypericum perforatum* as well as *Alchemilla* sp. (Kotońska, 1991; Pacyna, 2004; Gołek et al., 2015).

Many of the aforementioned species were recorded in group B, which was referred to in this article as 'used hay-meadow' (Appendix 1 – Tab. 3). However, contrary to typical *Gladiolo-Agrostietum* meadow, this group did not have *Gladiolus imbricatus*. It was found to contain numerous species of grasses for grazing and a group of legumes, proving that the analysed plots are useful from the agricultural standpoint. Nevertheless, this group of plots shows certain symptoms of meadow degradation because of the presence of species such as *Anthoxanthum odoratum* or *Nardus stricta*. The most probable hypothesis is that, as a result of incorrect care, this type of meadows are gradually turning into *Anthoxantho-Agrostietum* pastures which, according to some authors, are becoming increasingly common throughout Beskidy (Gołek et al., 2015). This plant community usually emerges as a result of discontinuation of usage or inadequate fertilisation of hay-meadows. Although they are considered pasturable plant communities, only extensive farming activities are conducted on them. The difference between typical used hay-meadows and *Anthoxantho-Agrostietum* pasture is in terms of its physiognomy, namely, its vegetation is much lower and less abundant. This plant community is dominated by quite low and feeble grasses, such as *Agrostis capillaris*, *Festuca rubra*, and *Anthoxanthum odoratum*. *Anthoxantho-Agrostietum* is gradually replacing *Gladiolo-Agrostietum* meadows to become a dominating feature of many glades (Gołek et al., 2015). The plots which were included in the hay-meadow group (Appendix 1 – Tab. 3) are most likely the various stages of transition of *Gladiolo-Agrostietum* towards *Anthoxantho-Agrostietum*.

Fig. 3. Former Hala Rzycka – now completely covered with forest; October 2015 (Photo. J. Przemysław Kubik)

After discontinuation of grazing, mowing, and other usable treatments, mountain glades experience secondary succession consisting in, among others, the return of forests to the areas previously occupied by them (Fig. 3). The changes that ensue involve not only plants but the entire landscape (Kornaś, 1990; Kaźmierczakowa, Poznańska, 1992; Zarzycki, Kaźmierczakowa, 2007; Zarzycki, 2008; Barabasz-Krasny, 2010). Initially, the overall number of species increases because the patches now contain plants from various communities – meadows and pastures as well as shrubs and trees (Radkowski, Barabasz-Krasny, 2007; Barabasz-Krasny, 2010). An example of this in the current floristic studies of the Beskidy glades is 'unused plots with shrubs' – group D. This group has the highest number of species in the floristic table among all four distinguished groups and a high value of the general diversity (H) and dominance (C) indicators (Fig. 2; Tab. 6). When the photophilous species associated with open areas are completely eliminated, the general species diversity of such plots will also decline (Zarzycki, Kaźmierczakowa, 2007; Barabasz-Krasny, 2010), especially since some clearly dominant species are in plots of this group now, e.g., *Rubus* sp., *Vaccinium myrtillus* (Appendix 1 – Tab. 5). Although unused plots with shrubs are characterised by large general diversity, the average number of species in the plot has been relatively low, which is evidence for the instability of floristic composition and dynamically occurring species replacement processes.

Fig. 4. Unused plot with *Pteridium aquilinum* – plot No 50: Zamczysko Jaskinia Lodowa I (Photo. J. Przemysław Kubik)

Similar processes were observed in plots characterised by a presence of a single dominating plant, namely unused plots with *Pteridium aquilinum* (Appendix 1 – Tab. 4; Fig. 4). In those plots, the meadow species still occur but in lower quantities, because they are overshadowed and dominated by *Pteridium aquilinum*. This clearly affects the general species diversity of such phytocoenoses (Appendix 1 – Tab. 4; Tab. 6). In this case, photophilous plant species, which are typical to open areas, are eliminated even before the plots are overgrown by shrubs and trees, as confirmed by the lowest light indicator value (L) for this group of plots (Tab. 7). Additionally, the acidification of the soil and the reduction of the nitrogen content, which appear from unfavourable flora changes as a result from the cessation of the use of meadows and pastures and the abandonment of care treatments, also promote the process of species elimination.

Conclusions

The results obtained through the conducted research confirm the thesis that the cessation of grazing, mowing, and other usable treatments leads to the disappearance of abundant meadow phytocoenoses as well as the depletion and loss of their diversity. Unused plots are characterised by lower average number of species. The plants that grow on them usually include trees and shrubs, which supplant grasses and other spe-

cies typical for hay-meadows. Cessation of grazing and other usable treatments results among other in reduction of the average number of species in plot, the increase of dominance indicators, and the reduction of pH and nitrogen content in soil.

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Appendix 1

Tab. 1. Location of the studied areas

Number of plot in area	Name of glade	Geographical coordinates	Altitude (m.a.s.l.)
	used glades		
1.	Kocoń	49°44′01″N 19°24′04″E	560
2.	Polana Gałasie	49°44′43″N 19°24′00″E	670
3.	Gibasów Groń	49°45′11″N 19°22′26″E	820
4.	Skolarówka	49°44′31″N 19°20′50″E	680
5.	Przełęcz Płonna	49°44′45″N 19°18′43″E	700
6.	Zamczysko Jaskinia Lodowa	49°44′56″N 19°18′15″E	740
7.	Kocierz Basie	49°45′54″N 19°20′56″E	640
8.	Kocierz Kiczora	49°46′03″N 19°19′49″E	630
9.	Kocierz Sołdrówka	49°45′45″N 19°19′29″E	530
10.	Kocierz Mieszczaki	49°45′44″N 19°18′34″E	560
11.	Wysokie	49°45′40″N 19°16′45″E	540
12.	Groń Jana Pawła II	49°47′40″N 19°26′48″E	850
13.	Podbucznik	49°46′21″N 19°27′06″E	670
14.	Targoszów Pagórek	49°46′09″N 19°27′08″E	620
15.	Targoszów Wieczorki	49°45′54″N 19°27′24″E	540
16.	Gronik	49°45′31″N 19°27′46″E	520
17.	Krzeszów Harańczykówka	49°45′50″N 19°28′32″E	500
18.	Jaworzyna III	49°46′40″N 19°28′00″E	650
19.	Jaworzyna II	49°46′42″N 19°27′50″E	670
20.	Jaworzyna I	49°46′45″N 19°27′40″E	680
21.	Warmuzówka	49°48′54″N 19°30′43″E	420
22.	Jaszczurowa Gancarzówka	49°47′56″N 19°30′20″E	420
23.	Tarnawa	49°46′56″N 19°29′10″E	490
24.	Pod Makowską Górą	49°47′08″N 19°29′03″E	560
25.	Polana	49°47′54″N 19°28′30″E	640
26.	Targoszów Gajka	49°45′33″N 19°26′49″E	550
27.	Hala na Potrójnej	49°46′34″N 19°22′07″E	840
	unused glades		
28.	Warmuzówka	49°48′54″N 19°30′43″E	420
29.	Jaszczurowa Suszyce	49°48′23″N 19°30′39″E	400
30.	Jaśkowa Arka	49°48′07″N 19°28′17″E	730
31.	Polana Semikowa	49°47′12″N 19°27′04″E	800
32.	Pod Jaworzyną	49°46′42″N 19°27′41″E	640
33.	Polana Łazy	49°46′17″N 19°28′17″E	600
34.	Pod Palusową Górą	49°45′58″N 19°28′06″E	580
35.	Gronik	49°45′31″N 19°27′46″E	520
36.	Targoszów Jurczakówka	49°45′33″N 19°26′49″E	550

37.	Przełęcz Midowicza	49°47′35″N 19°26′46″E	850
38.	Polana – Leskowiec	49°47′17″N 19°26′43″E	890
39.	Gancarz	49°46′37″N 19°26′58″E	800
40.	Pagórek	49°46′08″N 19°27′06″E	610
41.	Targoszów Wieczorki	49°45′47″N 19°27′26″E	520
42.	Targoszów Ćwiękałówka	49°45′35″N 19°26′09″E	660
43.	Polana Zaprzelina	49°46′20″N 19°21′14″E	760
44.	Kocoń	49°44′04″N 19°24′06″E	560
45.	Gałasie I	49°44′37″N 19°24′13″E	650
46.	Gałasie II	49°44′50″N 19°23′46″E	720
47.	Polana – Pietrasowa	49°44′51″N 19°23′19″E	800
48.	Gibasów Groń	49°45′08″N 19°22′24″E	800
49.	Czarne Działy	49°44′58″N 19°21′25″E	780
50.	Zamczysko Jaskinia Lodowa	49°44′53″N 19°18′23″E	740
51.	Ścieszków Groń	49°44′52″N 19°18′04″E	760
52.	Kocierz Walaszki	49°45′56″N 19°20′18″E	570
53.	Kocierz Basie	49°45′54″N 19°21′10″E	620
54.	Słonków	49°45′58″N 19°22′04″E	760

Tab. 2. Floristic composition and species coverage [%] in plots of pasture with *Nardus stricta*; + – species occurring in less than 1%

Successive number of plot	1	2	3	4	5	6	7	8	9	10	
Number of plot in area	7	5	27	4	3	12	18	2	26	20	Number of occurrence
Group in dendrogram					A						
Number of species in plot	28	24	29	16	12	19	20	18	24	18	
Grass and sedges											
Festuca rubra	15	40	15	15	40	15	15	15	15	40	10
Poa trivialis	15	15	15	15	3	15	15	15	65	15	10
Nardus stricta	15	3	15	15	15	3	3	15	3	.	9
Phleum pratense	+	.	3	3	.	3	.	.	+	3	6
Anthoxanthum odoratum	3	15	3	.	.	.	3	40	.	.	5
Dactylis glomerata	.	3	3	.	.	.	3	.	+	3	5
Carex rostrata	.	.	+	3	.	.	.	.	+	.	3
Legumes											
Trifolium repens	3	3	3	3	3	3	3	3	3	3	10
Vicia cracca	+	+	+	.	.	.	.	.	.	.	3
Other herbaceous species											
Hypericum perforatum	3	3	3	3	3	3	3	3	+	3	10
Achillea millefolium	3	+	+	3	3	3	+	3	+	+	10
Veronica chamaedrys	3	+	+	+	3	3	3	3	+	+	10
Rumex acetosa	+	3	+	3	15	3	3	3	3	3	10
Potentilla anserina	+	+	+	+	3	+	+	+	3	+	10
Juncus articulatus	3	3	+	+	+	.	+	3	+	+	9
Ranunculus acris	+	.	+	+	3	3	+	3	+	+	9

Leontodon hispidus	3	15	+	+	.	.	3	.	+	+	7
Plantago lanceolata	+	+	+	.	.	.	3	3	+	+	7
Stellaria graminea	3	+	3	+	.	3	.	.	.	+	6
Lychnis flos-cuculi	+	.	+	.	.	.	+	3	+	+	6
Campanula patula	+	+	+	.	.	+	.	.	+	.	5
Leucanthemum vulgare	+	+	+	.	.	.	+	.	+	.	5
Ajuga reptans	.	+	+	+	.	.	.	.	.	+	5
Cruciata glabra	.	.	.	.	.	+	3	.	+	3	4
Alchemilla monticola	.	.	.	.	.	+	+	+	+	.	4
Aegopodium podagraria	+	.	.	.	.	+	.	.	+	.	3
Pteridium aquilinum	.	.	.	.	+	.	+	3	.	.	3
Trees and shrubs											
Rubus sp. (c)	.	3	+	.	.	+	.	.	.	.	3

Species occurring sporadically
Grass and sedges: *Arrhenatherum elatius* 27:+. Legumes: *Vicia grandiflora* 7:3, 5:+; *Trifolium pratense* 7:+, 27:3. Other herbaceous species: *Carlina acaulis* 7:+, 5:+; *Viola arvensis* 7:+, 5:+; *Urtica dioica* 7:+, 2:+; *Scabiosa* sp. 5:+, 12:+; *Veronica officinalis* 27:+, 26:+; *Cirsium rivulare* 2:+, 26:+; *Fragaria vesca* 7:+; *Galium verum* 7:+; *Rhinanthus minor* 27:+, *Senecio integrifolius* 27:+; *Dianthus deltoides* 12:+.

Tab. 3. Floristic composition and species coverage [%] in plots of hay-meadow; + – species occurring in less than 1%

Successive number of plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Number of plot in area	11	6	19	10	9	25	8	15	13	17	16	23	1	22	21	24	14	Number of occurrence
Group in dendrogram									B									
Number of species in plot	22	18	22	22	28	22	23	23	22	22	21	22	23	22	27	20	22	
Grass and sedges																		
Festuca rubra	15	15	15	15	40	15	.	40	40	40	40	15	40	40	15	15	40	16
Poa trivialis	15	15	15	15	15	15	15	.	3	15	15	15	15	15	15	15	15	16
Dactylis glomerata	40	15	3	15	3	3	15	3	+	.	.	3	3	3	15	3	+	15
Phleum pratense	15	3	.	15	3	65	+	+	.	+	3	.	3	3	3	3	.	13
Anthoxanthum odoratum	.	3	3	3	+	3	15	3	3	15	3	3	15	.	.	+	.	13
Arrhenatherum elatius	15	15	3	.	.	.	.	3	3	.	3	15	15	15	15	.	.	10
Holcus lanatus	.	.	.	+	.	.	40	15	.	15	15	15	.	3	3	3	+	10
Nardus stricta	.	.	3	.	.	.	.	.	.	+	.	.	.	3	3	3	3	6
Lolium perenne	.	.	.	3	.	.	.	+	.	.	.	3	.	.	.	.	.	3
Legumes																		
Trifolium repens	15	.	3	3	15	15	15	15	3	+	15	3	3	3	3	3	+	16
T. pratense	+	.	.	+	3	+	3	15	3	3	.	.	3	+	3	.	.	11
Vicia grandiflora	+	3	+	+	3	.	+	.	+	+	.	.	+	.	.	.	.	9
Vicia cracca	+	.	.	.	.	.	.	+	.	+	.	.	.	.	+	.	.	4

Other herbaceous species																		
Rumex acetosa	+	3	3	3	+	+	+	.	3	.	+	+	3	+	+	+	+	15
Achillea millefolium	3	3	+	+	+	+	.	+	+	+	+	+	.	3	+	+	+	15
Hypericum perforatum	+	+	+	+	+	+	+	+	+	+	+	.	.	.	+	+	+	14
Ranunculus acris	+	+	+	+	+	.	3	+	+	3	+	+	3	.	.	.	+	13
Leontodon hispidus	+	+	+	.	+	+	+	3	+	.	.	+	.	3	+	+	+	13
Taraxacum officinale	.	3	.	.	+	+	+	+	+	.	.	+	+	+	3	3	+	12
Leucanthemum vulgare	.	.	.	+	+	+	+	+	+	+	+	+	+	+	+	.	.	12
Plantago lanceolata	.	3	.	.	+	.	+	3	3	+	+	+	3	.	3	.	3	11
Stellaria graminea	.	.	+	+	+	+	+	+	.	+	+	+	+	.	.	+	.	11
Veronica chamaedrys	+	3	+	+	3	+	3	+	.	.	.	.	.	.	+	.	+	10
Potentilla anserina	+	.	+	.	+	.	+	.	.	+	.	+	+	.	+	+	+	10
Campanula patula	+	.	.	.	.	+	.	+	+	.	3	.	.	+	+	+	+	9
Juncus articulatus	.	.	.	.	+	+	.	.	+	+	+	.	3	+	+	.	+	9
Alchemilla monticola	+	+	.	+	+	.	+	.	.	.	+	+	3	.	.	.	.	8
Aegopodium podagraria	3	+	+	+	+	.	3	.	.	.	.	.	.	.	+	.	.	7
Lychnis flos-cuculi	.	.	.	+	.	+	.	+	.	+	+	.	.	.	.	+	+	7
Senecio integrifolius	.	.	.	.	.	.	.	+	+	.	.	.	.	+	+	+	+	6
Euphorbia cyparissias	+	+	3	.	.	.	.	.	.	.	.	.	.	+	.	.	.	4
Fragaria vesca	+	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	4
Viola arvensis	.	.	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.	4
Rhinanthus minor	.	.	.	.	+	.	.	+	+	+	.	.	.	.	.	.	.	4
Galium verum	.	.	.	.	.	.	+	.	.	.	.	+	.	+	+	.	.	4
Cruciata glabra	.	.	3	.	.	.	.	.	.	.	+	+	.	.	+	.	.	4
Urtica dioica	3	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	3
Pteridium aquilinum	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	3
Plantago major	.	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	3
Ajuga reptans	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	+	3
Cirsium rivulare	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	3
Trees and shrubs																		
Rubus sp. (c)	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	3

Species occurring sporadically
Grass and sedges: *Carex rostrata* 9:+. Legumes: *Trifolium dubium* 16:+, 1:+. Other herbaceous species: *Dactylorhiza majalis* 17:+, 23:+; *Lamium maculatum* 9:+; *Dianthus deltoides* 25:+; *Digitalis purpurea* 25:+; *Humulus lupulus* (c) 1:3; *Bellis perennis* 1:+; *Juncus conglomeratus* 22:+; *Convolvulus arvensis* 22:+.
Trees and shrubs: *Rosa canina* (c) 22:+.

Tab. 4. Floristic composition and species coverage [%] in unused plots with *Pteridium aquilinum*; + – species occurring in less than 1%

Successive number of plot	1	2	3	4	5	
Number of plot in area	52	45	50	43	41	Number of occurrence
Group in dendrogram	C					
Number of species in plot	15	15	23	18	18	
Grass and sedges						
Festuca rubra	15	+	3	3	3	5
Poa trivialis	+	+	+	3	3	5
Agrostis capillaris	15	+	+	.	.	3
Phleum pratense	+	+	3	.	.	3
Nardus stricta	15	.	.	.	3	2
Legumes						
Vicia grandiflora	+	+	+	.	.	3
Other herbaceous species						
Pteridium aquilinum	15	90	90	90	90	5
Hypericum perforatum	+	+	3	+	+	5
Stellaria graminea	+	+	+	+	3	5
Potentilla anserina	+	.	+	+	.	3
Juncus articulatus	+	.	+	+	.	3
Rumex acetosa	.	.	+	+	+	3
Veronica chamaedrys	.	.	+	+	+	3
Trees and shrubs						
Acer pseudoplatanus (a)	.	.	+	+	+	3
Rubus sp. (b)	15	3	+	15	15	5

Species occurring sporadically
Grass and sedges: *Holcus lanatus* 52:3, 45:3; *Anthoxanthum odoratum* 52:+, 43:+; *Carex rostrata* 45:+; *Lolium perenne* 41:3; *Arrhenatherum elatius* 41:+. Legumes: *Vicia cracca* 45:+, 50:+; *Trifolium pratense* 50:+; T. repens 50:+. Other herbaceous species: *Juncus conglomeratus* 52:3, 43:3; *Senecio integrifolius* 45:+, 43:+; *Galeopsis* sp. 45:+, 41:+; *Leontodon hispidus* 45:+, 41:+; *Achillea millefolium* 50:+, 41:+; *Aegopodium podagraria* 50:+, 41:+; *Ranunculus acris* 50:+; *Scabiosa* sp. 50:+; *Vaccinium myrtillus* 43:15; *Veronica officinalis* 43:+; *Campanula patula* 41:+; *Leucanthemum vulgare* 41:+. Trees and shrubs: *Betula pendula* (a) 50:+, 43:15; *Picea abies* (a) 50:+, 43:15.

Tab. 5. Floristic composition and species coverage [%] in unused plots with shrubs; + – species occurring in less than 1%

Successive number of plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Number of plot in area	40	34	36	35	37	33	31	30	38	42	32	28	29	51	48	47	44	54	39	49	53	46	Number of occurrence
Group in dendrogram	D																						
Number of species in plot	21	28	23	18	10	17	17	15	15	22	22	17	14	15	17	17	22	21	18	18	14	21	
Grass and sedges																							
Festuca rubra	3	15	15	15	3	3	15	15	3	15	15	.	15	3	15	15	15	15	3	15	15	3	21

Poa trivialis	3	.	15	15	+	15	15	15	15	3	15	3	.	+	15	15	3	.	3	40	.	+		18
Nardus stricta	.	.	3	3	3	3	15	15	15	15	15	3	.	.	+	3	3	15	3	3	3	15		18
Holcus lanatus	.	+	+	3	.	.	.	.	.	.	.	3	15	+	3	.	+	3	.	.	3	15		11
Dactylis glomerata	3	.	+	+	.	.	.	.	.	.	+	3	.	.	+	3	+	.	+	.	.	.		9
Phleum pratense	3	15	.	15	.	.	.	.	.	.	3	.	.	.	.	+	3	+	+	.	.	.		8
Agrostis capillaris	.	.	.	.	.	.	.	.	.	.	.	.	.	3	15	3	15	15	.	15	15	+		8
Arrhenatherum elatius	+	+	+	.	.	.	.	.	.	.	3	15	.	+	.	.	+	.	.	.	.	.		7
Anthoxanthum odoratum	.	.	.	.	.	+	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	+		5
Carex rostrata	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.		3
Legumes																								
Vicia cracca	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	+	3	.	.	.	.	.		5
Vicia grandiflora	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.		4
Other herbaceous species																								
Hypericum perforatum	+	+	+	.	+	+	.	+	.	+	3	+	.	+	+	3	3	3	+	+	+	+		18
Potentilla anserina	+	+	+	+	+	+	+	+	+	+	+	.	+	.	.	+	+	3	+	+	.	.		17
Stellaria graminea	3	+	40	+	.	.	+	+	.	+	.	.	.	+	+	+	.	+	.	+	3	.		13
Rumex alpinus	+	+	+	+	+	+	+	+	+	.	.	.	.	+	3	.	.	.	.	+	.	+		13
Senecio integrifolius	+	+	+	.	.	.	.	.	.	.	+	.	3	.	.	.	+	+	+	.	+	+		10
Juncus articulatus	.	+	.	.	+	.	+	.	.	+	+	.	+	.	.	.	.	+	.	+	.	+		9
Achillea millefolium	3	+	.	.	.	.	.	.	.	+	+	+	3	.	+	.	.	.	.	+	.	.		8
Veronica chamaedrys	+	+	3	.	.	.	.	.	.	+	+	.	.	.	+	.	.	+	+	.	.	.		8
Leontodon hispidus	+	+	.	.	.	.	.	.	.	.	+	.	3	.	.	.	+	.	+	+	.	+		8
Juncus conglomeratus	.	.	3	40	.	15	.	+	.	+	.	.	.	.	.	.	.	.	+	+	3	.		8
Vaccinium myrtillus	.	.	.	.	.	3	90	65	90	.	.	.	.	.	.	40	.	3	3	.	.	40		8
Ranunculus acris	+	+	+	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.		6
Veronica officinalis	.	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	+	+	.	.	+		6
Cirsium rivulare	.	+	3	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.		5
Aegopodium podagraria	.	+	+	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.		5
Galeopsis sp.	.	.	.	+	.	.	+	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.		5
Campanula patula	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+		4
Leucanthemum vulgare	.	+	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.		4
Urtica dioica	.	.	+	+	.	.	.	.	.	.	.	3	.	+	.	.	.	.	.	.	.	.		4
Pteridium aquilinum	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	+	.			4
Plantago lanceolata	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.		3
Equisetum sylvaticum	.	.	+	+	.	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		3

Trees and shrubs																								
Betula pendula (a)	.	.	.	.	.	3	+	3	+	15	+	+	15	40	.	.	3	3	65	15	65	15		15
Picea abies (a)	.	.	.	.	.	.	.	.	15	.	.	.	.	.	.	.	.	15	40	15	.	.		4
Acer pseudoplatanus (a)	.	.	.	.	.	.	.	.	+	.	.	.	.	90	3	.	.	.	.	+	.	.		4
Rubus sp. (b)	65	40	+	3	90	15	3	15	3	15	40	15	+	3	+	3	15	15	15	65	3	15		22
Frangula alnus (b)	3	40	+	40	65	3	.	.	3	.	.	.	+	.	.	+	+	+	+	.	+	+		14
Sorbus aucuparia (b)	3	.	.	.	.	+	+	.	3	.	.	.	.	.	+	+	3	+	+	+	+	+		12
Crataegus sp. (b)	15	.	3	.	.	.	.	.	.	3	.	.	.	.	3	.	.	+	.	.	.	+		6
Rosa canina (b)	.	.	.	.	.	.	.	.	.	15	.	65	+	.	.	.	3	.	.	.	.	.		4

Species occurring sporadically

Grass and sedges: *Lolium perenne* 51:+, 44:+; *Cynosurus cristatus* 34:+. Legumes: *Trifolium repens* 42:+, 32:3; *T. pratense* 42:+. Other herbaceous species: *Lychnis flos-cuculi* 34:+, 42:+; *Dactylorhiza majalis* 34:+, 47:+; *Alchemilla monticola* 34:+, 46:+; *Galium verum* 36:+, 28:3; *Polytrichum commune* (d) 33:3, 38:+; *Scabiosa* sp. 40:+; *Plantago major* 34:+; *Briza media* 36:+; *Veratrum lobelianum* 31:3; *Ajuga reptans* 31:+; *Digitalis purpurea* 30:+; *Juncus effusus* 38:+; *Taraxacum officinale* 32:+; *Fragaria vesca* 29:15; *Cruciata glabra* 29:+; *Euphorbia cyparissias* 29:+; *Gladiolus imbricatus* 54:+; *Carlina acaulis* 49:+. Trees and shrubs: *Pinus sylvestris* (a) 33:3, 28:+; *Quercus robur* (a) 40:+; *Fagus sylvatica* (a) 31:+; *Abies alba* (a) 30:+; *Larix decidua* (a) 46:+.

Abstract

The influence of grazing, mowing, and other usable treatments on the flora diversity of glades in the Beskid Mały in southern Poland was investigated. The field research was carried out between 2015 and 2016. Flora analysis consisted mainly of comparing the botanical composition of glades abandoned for several decades with the botanical composition of glades currently used as pastures. On selected plots, botanical composition was determined using the Klapp (1965) estimation method. All floristic lists from the study plots were analysed by using hierarchical numerical classification. Based on the numerical classification of plots on analysed glades in the Beskid Mały, four utility-floristic groups were distinguished: pasture with *Nardus stricta* A, hay-meadow B, unused plots with *Pteridium aquilinum* C, and unused plots with shrubs D. The results of studies confirm the thesis that species composition is a reflection of management practices or lack thereof. It was demonstrated that the cessation of the grazing and mowing on the mountain glades of Beskidy caused adverse changes in the structure of species composition and a reduction in floristic diversity. Initially, it causes an increase in the number of species in the sward, followed by elimination of the photophilous species, which lowers general species richness.

Key words: Klapp estimation method, meadows and pastures, mountain pasturage, succession

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Sukcesja nieużytkowanych polan i jej wpływ na zróżnicowanie flory w Beskidzie Małym (Południowa Polska)

Streszczenie

Zbadano wpływ zaprzestania działalności pasterskiej i łąkarskiej oraz innych zabiegów użytkowych na zróżnicowanie flory hal oraz polan w Beskidzie Małym w Południowej Polsce. Badania w terenie wykonano w latach 2015–2016. Analiza florystyczna polegała głównie na porównaniu składu botanicznego polan od kilkudziesięciu lat odłogowanych, ze składem botanicznym polan aktualnie użytkowanych gospodarką pasterską. Skład botaniczny określono na wybranych poletkach, przy pomocy metody szacunkowej Klappa (1965). Wszystkie spisy z analizowanych poletek poddano hierarchicznej klasyfikacji numerycznej. Na podstawie klasyfikacji numerycznej poletek wyróżniono na badanych polanach Beskidu Małego cztery grupy florystyczno-użytkowe: pastwisko z *Nardus stricta* A, łąka kośna użytkowana B, płaty nieużytkowane z *Pteridium aquilinum* C oraz płaty nieużytkowane zakrzaczone D. Badania potwierdzają tezę, że skład gatunkowy jest odzwierciedleniem prowadzonych zabiegów gospodarczych lub ich braku. Wykazano, że zaprzestanie gospodarki pasterskiej i kośnej polan górskich w Beskidach skutkuje niekorzystnymi zmianami w strukturze gatunkowej runi oraz obniżeniem różnorodności florystycznej. Początkowo powoduje wzrost liczby gatunków w murawie, a następnie eliminację gatunków światłolubnych, co obniża ogólne bogactwo gatunkowe.

Słowa kluczowe: metoda szacowania Klappa, łąki i pastwiska, pasterstwo górskie, sukcesja

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