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KALINA ADAMCZYK, MAŁGORZATA JANKOWSKA-BŁASZCZUK
ALOJZY PRZEMYSKI

Zakład Botaniki, Instytut Biologii, Uniwersytet Jana Kochanowskiego w Kielcach
25-406 Kielce, ul. Świętokrzyska 15, e-mail: mjanko@ujk.edu.pl

Changes of species richness with special consideration of threatened species within the overgrowing xerothermic grassland in the forest clearing reserve of "Polana Polichno" in the Nida Basin (Małopolska Upland)

Zmiany bogactwa gatunkowego zarastającej murawy kserotermicznej leśnej polany ze szczególnym uwzględnieniem gatunków zagrożonych wyginięciem w rezerwacie "Polana Polichno" (Niecka Nidziańska,Wyżyna Małopolska)

SUMMARY

The aim of the study was to show the changes of species number and their frequency in different patches of xerothermic grasslands in the period of 2–3 years, as well as relation between the number and frequency of species which were classified in four ecological groups. We wanted to investigate changes in the frequency of several most threatened species: *Cephalanthera damasonium, Adonis vernalis, Lathyrus pannonicus, Linum hirsutum, Sesleria uliginosa* and *Orchis purpurea*. The observations were carried out on 120 m^2 permanent plots situated in the clearing forest reserve "Polana Polichno" in the Ponidzie region. Plots were chosen within the ecotone zone and in the central part of the reserve which represented different management regimes. It was found that within the same patches the mean number of species per 1m^2 did not differ significantly in the period of 2–3 years. The study showed a distinctly higher density of species in patches of grassland situated in the central part of the clearing in comparison with the ecotone patches, especially in the patch where trees and bushes had been cut down a few years earlier. Moreover, an increase in the number of grassland species and decrease in the number of forest herbs species was noted in the ecotone patch which had been permanently cut.

STRESZCZENIE

Celem naszych badań było pokazanie zmian, jakie nastąpiły w okresie 2–3 lat w liczbie i frekwencji gatunków rosnących w zróżnicowanych płatach murawy kserotermicznej. W pracy pokazano również zmiany we frekwencji kilku szczególnie zagrożonych gatunków, takich jak: *Adonis vernalis, Cephalanthera damasonium, Lathyrus pannonicus, Linum hirsutum, Orchis purpura, Sesleria uliginosa.* Analizowano również, jak zmienia się liczba i frekwencja gatunków w wyróżnio-

nych przez autorów grupach ekologicznych. Obserwacje prowadzono na 120 m^2 stałych powierzchni badawczych usytuowanych w rezerwacie Polana Polichno, położonego w obrębie Ponidzia. Powierzchnie badawcze założono w strefie ekotonu, jak również w centralnej części rezerwatu w miejscach o zróżnicowanej historii użytkowania. Stwierdzono, że w obrębie tych samych płatów średnia liczba gatunków na $1m^2$ nie zmieniła się istotnie. Obserwacje wykazały natomiast znacząco wyższe zagęszczenie gatunków w płatach w centralnej części polany w porównaniu z płatami ekotonowymi, szczególnie z płatem, gdzie kilka lat wcześniej wycięto drzewa i krzewy. Stwierdzono również znaczący wzrost udziału gatunków kserotermicznych i spadek liczby gatunków zielnych leśnych w płacie ekotonowym, gdzie prowadzono stałe koszenie.

Key words: species richnes, xerothermic grassland, threatened species, ecological structure, ecotone, Ponidzie region

INTRODUCTION

Limestone grasslands are commonly known as the one of the most species-rich communities in the whole of Europe (14, 23). There are many hypotheses and theories that have been proposed to explain the high species diversity in such ecosystems (17). Ecologists try to find the mechanism of species existence through differentiated fertilization and management regime experiments (2, 3, 4, 7, 20, 21, 22)

Another issue is the prevention of disappearance of the communities that exist due to very specific, permanent human impact (16, 17). Cessation of the traditional agricultural use of the xerothermic grassland areas is the common phenomenon in the whole of Europe. The result is the decline of species diversity due to colonization of the area by bushes and trees and some grasses, especially *Brachypodium pinnatum* as well as eutrophisation of the environment (8, 9) Secondary successions proceed very quickly especially in places in the close neighborhood of forest (1, 10). The result of these processes is first of all the decrease of species richness associated with disappearing of rare dicot grasslands species, which is commonly explained by their low tolerance for shade. The ecotone zone at the border of grassland and forest is overgrown by bushes and trees in a very short time: at the same time colonization of trees and bushes also in central parts of grasslands can be observed (10, 18).

Our paper shows the changes in species richness as well as in the participation of particular groups of species within 2–3 years in xerothermic grassland patches situated within the forest/grassland ecotone zone and in the interior of the xerothermic grassland Polana Polichno reserve.

In ecotone patches we compared the changes in the number and frequency of flowering plants species between two sets of plots (patches): one was situated in the place where bushes had been cut in the year preceding the observation (Ek) and the other in that part of ecotone where open, permanently managed grasslands bordered with forest (Ebk). Within the interior of the reserve we distinguished two grassland patches – one completely not shaded (M1) and the other with juniper bushes covering 15–20% of the area (M2).

The aim of the studies was to show the changes in species richness in different patches of grasslands in the period of 2–3 years, as well as relation between the number and frequency of species which were classified in four ecological groups: "a" – xerothermic grassland species; "b" – trees and shrubs; "c" – forest herbs; "d" – meadow and synantropic species. Because in managing a nature reserve it is important to understand expected effects on individual species, the aim was also to investigate changes in the frequency of several species which were growing on established plots: *Adonis vernalis, Cephalanthera damasonium, Lathyrus pannonicus, Linum hirsutum, Orchis purpurea* and *Sesleria uliginosa.* All these species are noted in the Polish Red Book in category VU, which means they are vulnerable to extinction. Some of them like *Lathyrus pannonicus* are exeptionaly rare in Poland.

STUDY AREA

The studies were conducted in one of the floristically most interesting xerothermic grassland reserves: Polana Polichno. The reserve is situated in the Garb Wodzisławski mesoregion, in the Ponidzie region about 7 km SSE of Pińczów (11), (Fig. 1).

The remnant xerothermic grassland clearing, surrounded by the *Tilio-Carpinetum* forest, contains about 370 species of vascular plants, mainly typical of xerothermic grasslands and forest edges communities (6). Originally, all the area was covered by the deciduous forest, which is documented on old 19th century maps. The clearing was formed as a result of cutting trees, after which the area was used as a field and then pasture. The documents show that in the mid last century, the clearing was forested but such management totally failed because deciduous tree seedlings died due to lack of water.

After establishing the reserve, the whole area of the clearing was excluded from any agricultural usage. The effect of such strict protection was the colonization of the clearing by bushes, mainly with *Juniperus communis* and *Cornus sanguinea*. For several years the bushes were cut and removed from the interior of the reserve as well as from the ecotone zone between the grassland and the surrounding forest. The grassland in the "Polana Polichno" reserve is one of the most valuable xerothermic communities of *Adonido-Brachypodietum pinnati*. Two variants of the community (typical and with *Pinus sylvestris*) were distinguished there (18). Within the typical form of the grassland community, the shrub canopies layer reaches the cover between several to 20% (the most common is *Juniperus communis*). The very dense and species rich herb layer contains about 140 species of vascular plants, moss layer is rather sparse (18).

METHODS

In the "Polana Polichno" reserve four patches were distinguished, two situated in the zone adjacent to the forest edge (Ek, Ebk) and two in the central part of the clearing (M1, M2). Patch Ek represented places newly revealed by removing the bushes, mainly *Cornus sanguinea, Prunus spinosa* and *Frangula alnus* whereas patch Ebk was situated in the ecotone fragments where open, not overgrown grassland reached the border of the forest. The patch M1 distinguished in the interior of the clearing was also without any bushes and trees as opposed to M2 which was partially shaded by juniper shrubs (they covered approximately 15–20%). Within each of the mentioned patches the sets of permanent plots sized 2 x 15 m, divided into 30 x 1m^2 subplots, were established in 2004. For each 1m^2 subplot the list of the vascular plants species was made. The observations were repeated in early summer 2006 for ecotone patches and in 2007 in central grassland patches.

All noted species were categorized into one of four ecological groups as follows:

Group a – grassland species**,** which are characteristic of *Festuco-Brometea*, *Trifolio-Geranieta sanguinei classes*, order *Quercetalia pubescenti-petraeae* as well as others highly light-demanding and calciphilous species mainly of *Molinio-Arrhenatheretea* class (with index of soil acidity R = 5 and index of light L= 4 or 5, without synantropic species); (13, 24);

Group b – trees and shrubs**;**

Group c – forest herbs**,** species characteristic of *Querco-Fagetea* class and other shade tolerant species (light index value L= 1, 2 or 3); (13, 24);

Group d – other species, mainly meadow and synantropic

The similarity between the species composition of particular plots between years and between plots was measured by means of the similarity coefficient P (Jaccard-Steinhaus method) taking into account qualitative traits of species presence. In the formula P=2c/a+b it was assumed that c was the number of species common for two plots, a and b the number of species noted only in one of the plots compared. For estimating the differences between the frequency of species of given patches the Kruskal-Wallis test was employed. The nomenclature follows (15).

RESULTS

Species richness

Altogether on the 120 m^2 area 148 species were found during two-time observations which were carried out in the ecotone patches and in the grassland patches in years 2004–2006 and 2004–2007 respectively. As many as six of them are species vulnerable to extinction. Within the same patches the median number of species per 1m^2 did not differ significantly (Fig. 2). Nevertheless the differences in species densities between patches were significant (Fig. 3). Grassland patches M1 and M2 were characterized by the highest average densities of species oscillating between 21.6±2.7 a 26.7±4.45/m^2. Both ecotone patches showed significantly lower species richness but the lowest species densities, 9.0–10.8/m^2, were noted on the Ek patch which were overshaded by root sprouts growing anew (Fig. 3). The mean density of species in the ecotone patch which were regularly cut (Ebk) in comparison with Ek was higher by about one third and amounted to 15.3±4.7;16.01 ±2.51 in particular years.

Ecological group – changes in frequency and number of species

Grassland species – group "a"

In ecotone patches (Ek and Ebk) and in grassland patches (M1 and M2) 64 species from *a* group were noted during 2 years of observations. There were 55 species in M1 and M2 patches and only 30 species in ecotone patches Ek and Ebk. The mean number of the species between patches differed significantly (Table 1). One should emphasize the fact of the substantial increase of grassland species richness in the ecotone patch Ebk in years 2004–2006. At that time as many as 13 species appeared in the patch Ebk (Tab. 1). The change in the species structure of these patches is reflected by the relatively low rate of similarity Ebk_{2004}/Ebk_{20006}=0,58. As it turned out, the lowest number of grassland species was noted on the Ek patch. In 2004, in 4–5 months after cutting out shrubs only 8 species from "a" group were found, of which only *Melampyrum nemorosum*, *Melittis melissophyllum* and *Vincetoxicum hirundinaria* achieved the frequency above 10%. Quickly growing sprouts from the not removed carp root so strongly shaded the patch Ek that 2 years later the only species appearing there abundantly was *Melampyrum nemorosum*. Half of the species observed in 2004 disappeared and frequency of the remaining decreased considerably (Tab. l).

In the central part of the grassland the patches (M1 and M2) were characterized by a high species richness in both years of observations ($M1_{2004}$/$M1_{2007}$=0,82, M_{2004}/M_{2007}=0,85). The structure of the species composition was very similar. Very often there were observed *Brachypodium pinnatum*, *Thesium linophyllon*, *Medicago falcata*, *Viola hirta, Festuca rupicola, Carex michelii* and *Salvia pratensis.* The frequency of these species was above 70% in both years as well as in both pat-

ches. Some species like *Aster amellus, Carlina vulgaris, Crepis praemorsa, Laserpitium latifolium* evidently preferred places lightly shaded by juniper shrubs (patch M2).

Trees and shrubs – "b"group

Altogether 26 species of trees and shrubs were observed in the ecotone and central grassland patches. In contrast with "a"group of species, trees and shrubs grew more frequently in ecotone patches than in the central part of the reserve (Table 2). Some species like *Cornus sanguinea, Prunus spinosa, Euonymus verrucosa* were noted mainly in ecotone patches, while others like *Juniperus communis* and *Pinus sylvestris* in the central grassland. The similarity index between grassland and ecotone patches was low and amounted to 0.57. The comparison of grasslands patches between themselves showed that seedlings and juveniles of trees and shrubs appeared more often in the patch slightly shaded by junipers (M2) than in completely open grassland (M1). In contrast, within ecotone patches trees and shrubs grew mostly in the strongly shaded patch Ek (Tab. 2).

Forest herbs – "c"group

Table 3 shows a great divergence within the group between grassland and ecotone patches. Altogether we found 26 forest herbs species but only five of them grew in one of M patches; moreover, only *Cruciata glabra* was noted in both M1 and M2 patches in 2004 as well as in 2007. In the ecotone, 25 species were noted but in Ebk patch the number of the species evidently decreased from 21 in 2004 to 12 in 2007. At the same time in the Ek patch the number of species from this group did not change considerably but frequencies of some of them significantly increased: this especially concerned the species like *Asarum europaeum, Galium odoratum, Viola mirabilis.*

Meadow, synantropic species and others – "d"group

The species from the group were much more numerous and had a higher frequency in central grassland patches than in ecotone patches. Moreover there was a very low number of species common to both patch M and E. Within 32 species which were found only 10 grew in grassland patches M and ecotone patches E /similarity coefficient amounted to 0.5). In grassland patches the most frequent were: *Veronica chamaedrys, Coronilla varia* whereas in the ecotone zone *Galium aparine* (Table 4).

Changes of frequency of species vulnerable to extinction: Adonis vernalis, Cephalanthera damasonium, Lathyrus pannonicus, Linum hirsutum, Orchis purpurea, Sesleria uliginosa

It was found that *Adonis vernalis* appeared within the ecotone only in 2006 in the patch which was cut permanently (Table 1). The appearance of the *Adonis vernalis* was associated with essential changes of the species structure within the whole patch Ebk during the period of three years. During this time the species number did not change in the patch but the participation of grassland species grew from the 26% up to the 42%. Species appeared which had not been noticed earlier: *Salvia pratensis, Thalictrum minus, Laserpitium latifolium, Centaurea scabiosa, Filipendula vulgaris, Fragaria viridis*. The forest herb species ("c" group) which grew in the surrounding horn-bean forest retreated from this patch, e.g. *Anemone nemorosa, Ranunculus cassubicus, Sanicula europaea, Poa nemoralis, Melica nutans* and others. In the central part of the clearing *Adonis vernalis* was found in both patches M1 and M2 but it clearly preferred places with little shade thrown by juniper shrubs.

The frequency of the species was twice higher on M2 than on M1. The M2 patch was characterized by the over twice higher participation of trees and shrub species ("b" group) and generally higher species richness in each year of observation (Tab. 1, 2).

Our observations showed that *Lathyrus pannonicus* preferred similar microhabitat conditions. The species sporadically appeared in the ecotone, Ebk patch, in the third year of observation. However, in the central part of the reserve the species grew abundantly with 90% frequency only on M2 patch. In the patch totally open (M1) *Lathyrus* plants were very rare (Table 1).

Linum hirsutum was observed only in the central part of the clearing in M1 and M2 patches. Characteristic of this species was a very high changeability of its frequency. In the first year of observation it was not found in M1 patch and then after three years we noted it with a frequency of over 50%. Moreover, *Linum* plants were sporadically noted as well as in M2 patch and after three years they were absent in the patch (Tab. 1).

Out of all the threatened species observed here, *Sesleria uliginosa* appeared most rarely. It was noticed only once in M2 patch and after three years it was not found in the patch. *Orchis purpurea* was noted only in M2 patch.

Only one threatened forest species *Cephalanthera damasonium* was observed occasionally in Ebk patch with the constant frequency. The species was noted in a little more frequently the shaded patch Ek three years after removing of shrubs (Table 3).

DISCUSSION

Changes in species richness

It is commonly known that majority of xerothermic calcareous grasslands in Central Europe are maintained by mowing and grazing, and when left alone they will convert into shrub, pioneer forest and then into successional forest commu-

nities (2, 4, 5). The consequence of the changes is not only the total rebuilding of species structure of a community but also strong depletion of species richness. Many papers show that species densities on such areas achieve 10 to 27 species per 0.01 m^2 and even exceed 40 species per 1 m^2 (3, 12, 22).

Our observations confirm very high species densities in xerothermic grassland. In the ecotone part of the reserve the highest number of species amounted to 37/m^2 (in Ebk04 patch) whereas in the central part 32/m^2 (in M107 patch). At the same time th species richness of the surrounding forest oscillated between ten and twenty (19). One should emphasize that species densities in M1 and M2 plots did not decrease below 15/m^2 , while at the same time in th ecotone in Ek plots 5–6 species per 1m^2 was noted. The data from the Polichno reserve indicate a very fast decrease of species richness with light decline. Even in the place where grassland was regularly cut and was partly shaded only by the forest edge (Ebk), the mean density of species was significantly lower than in the central, not shaded part of the reserve (Fig. 3). The fastest decrease of species richness was noted in plots which were again shaded by root sprouts growing anew (Ek).

Changes in the ecological structure of grassland

Many studies have analyzed the changes in species richness and species composition of grassland community under different management regimes (3). It is commonly accepted that maintenance of biodiversity is strictly connected with supporting traditional methods of land use, especially mowing and grazing (7, 8, 9). In the Polichno reserve, which is a typical example of the clearing grassland refuge endangered by proceeding succession processes, the number of species within the distinguished ecological group in the managed ecotone zone (Ebk plots) changed considerably. We observed an increase in the number of grassland species and a decrease in the number of forest herbs species. It evidences the maintenance of grassland community in the ecotone within places which were not totally shaded. What is interesting is that some rare and endangered species like *Adonis vernalis* and *Lathyrus pannonicus* appeared in the plots of such places (Ebk). Quite a different tendency could be observed in Ek patch, where the decrease of species richness was accompanied by withdrawal of the grassland xerothermic plants. Within central plots (M1 and M2) the number of trees and shrubs species did not change but in M2 plot, which was only slightly shaded by juniper shrub, the number of trees and shrubs was three times higher than in M1. Also the number of forest herbs species was much higher there, which proves that even small juniper shade may create microhabitats which are successfully colonized by forest species. The observations which were carried out in the reserve on newly revealed gaps in the ecotone and in the central part of the clearing (18) showed that such places are successfully colonized by many forest species.

The flora of the Polichno reserve includes 38 protected, threatened and rare species within the group; 16 species are strictly protected and 9 are vulnerable to extinction (10). On the observed plots we noted as many as six species vulnerable to extinction. Some of them changed their frequency and after two or three years they were noted on other plots. Such wandering grassland species seems to be a specific feature of such unstable communities. It means that even small microhabitat changes resulting from changes in the regime of grassland management may have an effect on the abundance of especially valuable plant species which grow in small isolated populations.

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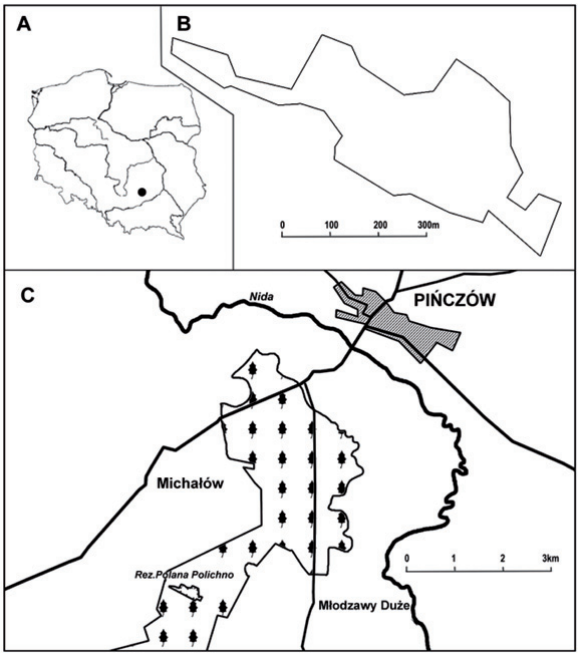

Fig. 1. Locality of the xerothermic grassland "Polana Polichno" reserve: A – situation in Poland; B – reserve border, C – regional locality

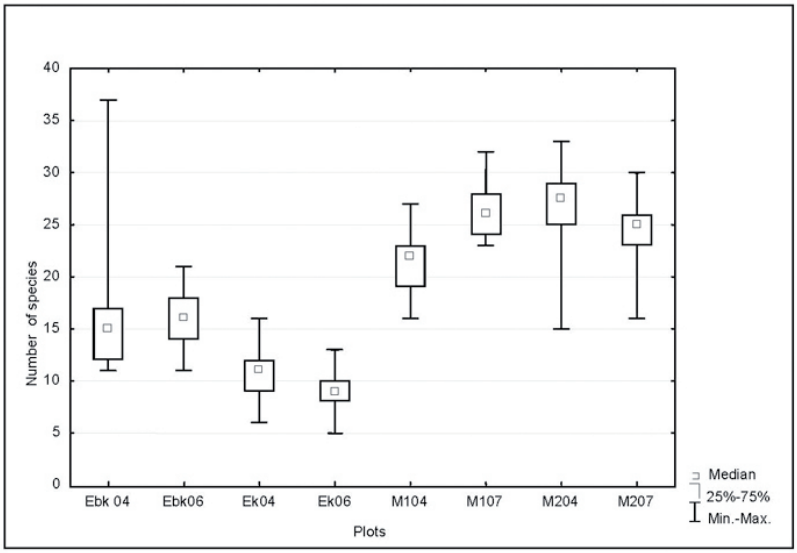

Fig. 2. Median of species densities per 1m^2 on plots situated in ecotone zones Ebk and Ek as well as in central part of grassland reserve M1 and M2. Each plot sized 30 m^2. Observations were made in 2004, 2006, 2007 in "Polana Polichno" reserve

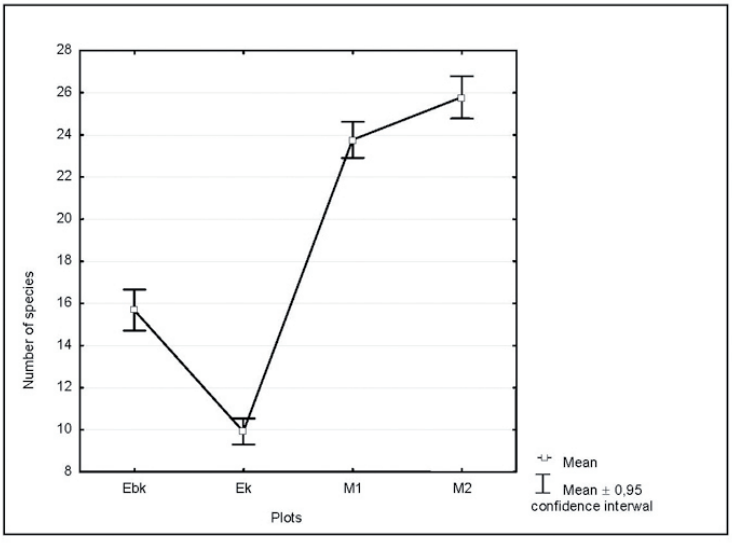

Fig. 3. Mean densities of species per 1m^2 in ecotone plots Ebk and Ek and in plots situated in central part of Polana Polichno reserve

Table 1. (continuation). Density and frequency (%) of xerotermic grassland species of "a" group growing on four patches (Ek, Ebk, M1, M2 each sized 30x1m^2).Observation in 2004, 2006 and 2007, Polana Polichno reserve

Lp.	Plots	Ebk04	Ebk06	Ek04	Ek06	M104	M107	M204	M207
	Mean number of species/m^2	15.3±4.74	16.1±2.5	10.8±2.53	9±1.86	21.6±2.73	25.9±2.22	26.7±4.45	24.9±3.0
	Mean number of „a" group species/m^2	4.03±1.8	7.97±2.55	1.5±0.93	1±0.45	17.3±2.6	19.8±1.97	20.97±4.03	18.3±3.15
	1	2	3	4	5	6	7	8	9
1	Species *Brachypodium pinnatum*	80	100	3.3	0	100	100	93.3	100
2	*Medicago falcata*	20	86.7	0	0	100	93.3	100	93.3
3	*Carex michelii*	0	50	0	0	90	93.3	83.3	83.3
4	*Peucedanum cervaria*	36.7	86.7	6.7	0	43.3	83.3	70	66.7
5	*Thesium linophyllon*	0	0	0	0	100	100	90	100
6	*Melampyrum nemorosum*	86.7	90	80	90	13.3	23.3	0	0
7	*Viola hirta*	3.3	10	0	0	96.7	100	80	80
8	*Festuca rupicola*	0	6.7	0	0	93.3	100	70	93.3
9	*Salvia pratensis*	0	6.7	0	0	93.3	83.3	83.3	73.3
10	*Fragaria viridis*	0	13.3	0	0	90	96.7	76.7	60
11	*Anemone sylvestris*	0	0	0	0	70	53.3	96.7	96.7
12	*Trifolium medium*	33.3	56.7	13.3	0	93.3	83.3	30	0
13	*Allium oleraceum*	6.7	30	3.3	3.3	86.7	63.3	43.3	50
14	*Asperula cynanchica*	0	0	0	0	73.3	96.7	50	23.3

	1	2	3	4	5	6	7	8	9
15	*Achillea pannonica*	0	0	0	0	86.7	43.3	90	20
16	*Centaurea scabiosa*	0	3.3	0	0	86.7	23.3	60	56.7
17	*Agrimonia eupatoria*	6.7	40	0	0	43.3	70	30	13.3
18	*Euphorbia cyparissias*	0	3.3	0	0	26.7	0	86.7	86.7
19	*Primula veris*	16.7	30	0	0	43.3	6.7	66.7	33.3
20	*Elymus hispidus*	0	0	0	0	33.3	96.7	56.7	0
21	***Lathyrus pannonicus***	**0**	**3.3**	**0**	**0**	**3.3**	**0**	**90**	**90**
22	*Galium verum*	0	0	0	0	36.7	23.3	46.7	43.3
23	*Carex tomentosa*	0	0	0	0	0	0	73.3	70
24	*Melittis melissophyllum*	53.3	53.3	26.7	6.7	0	0	0	0
25	*Plantago media*	0	0	0	0	30	66.7	23.3	16.7
26	*Trifolium montanum*	0	16.7	0	0	16.7	30	33.3	40
27	***Adonis vernalis***	**0**	**6.7**	**0**	**0**	**16.7**	**16.7**	**56.7**	**33.3**
28	*Campanula glomerata*	6.7	16.7	0	0	26.7	0	43.3	26.7
29	*Linum catharticum*	0	0	0	0	6.7	60	0	53.3
30	*Thymus marschallianus*	0	0	0	0	3.3	26.7	66.7	20
31	*Potentila arenaria*	0	0	0	0	26.7	56.7	23.3	6.7
32	*Vicia tenuifolia*	0	0	0	0	46.7	0	0	56.7
33	*Sanguisorba minor*	0	0	0	0	36.7	13.3	16.7	30
34	*Veronica teucrium*	0	0	0	0	66.7	0	26.7	0
35	*Aster amellus*	0	0	0	0	3.3	6.7	33.3	40
36	*Carlina acaulis*	0	0	0	0	3.3	3.3	40	33.3
37	*Orobanche lutea*	0	0	0	0	6.7	10	33.3	26.7
38	*Euphorbia angulata*	20	50	0	0	0	0	0	0
39	***Linum hirsutum***	**0**	**0**	**0**	**0**	**56.7**	**0**	**3.3**	**0**
40	*Laserpitium latifolium*	0	26.7	0	0	0	0	16.7	16.7
41	*Thymus kosteleckyanus*	0	0	0	0	6.7	13.3	23.3	13.3

	1	2	3	4	5	6	7	8	9
42	*Galium boreale*	3.3	0	0	0	6.7	0	26.7	13.3
43	*Veronica austriaca*	0	0	0	0	0	0	10	26.7
44	*Stachys recta*	0	0	0	0	3.3	20	6.7	6.7
45	*Crepis praemorsa*	0	0	0	0	0	0	23.3	10
46	*Thymus pannonicus*	0	0	0	0	26.7	0	0	3.3
47	*Cerinthe minor*	0	0	0	0	10	13.3	0	0
48	*Vincetoxicum hirundinaria*	10	0	13.3	0	0	0	0	0
49	*Arabis hirsuta*	0	0	0	0	3.3	16.7	0	0
50	*Scabiosa ochroleuca*	0	0	0	0	10	0	3.3	6.7
51	*Trifolium alpestre*	13.3	0	0	0	0	0	0	0
52	*Tanacetum corymbosum*	0	0	0	0	0	0	6.7	3.3
53	*Thymus glabrescens*	0	0	0	0	10	0	0	0
54	*Melampyrum arvense*	6.7	0	0	0	0	0	0	0
55	*Carex humilis*	0	0	0	0	0	0	6.7	0
56	***Orchis purpurea***	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6.7**
57	*Carex flacca*	0	0	0	0	0	0	0	3.3
58	*Carlina vulgaris*	0	0	0	0	0	0	3.3	0
59	***Sesleria uliginosa***	**0**	**0**	**0**	**0**	**0**	**0**	**3.3**	**0**
60	*Thymus serpyllum*	0	0	0	0	0	0	0	3.3
61	*Filipendula vulgaris*	0	3.3	0	0	0	0	0	0
62	*Thalictrum minus*	0	3.3	0	0	0	0	0	0
63	*Vicia sepium*	0	3.3	0	0	0	0	0	0
64	*Bromus benekenii*	0	0	3.3	0	0	0	0	0

Table 2. Density and frequency (%) of trees and shrubs species of "b" group growing on four patches (Ek, Ebk, M1, M2 each sized 30x1m²). Observations in 2004, 2006 and 2007 Polana Polichno reserve

Lp.	Plots	Ebk04	Ebk06	Ek04	Ek06	M104	M107	M204	M207
	Mean number of species/m²	15.3±4.74	16.1±2.5	10.8±2.53	9±1.86	21.6±2.73	25.9±2.22	26.7±4.45	24.9±3.0
	Mean number of „b" group species/m²	2.9±1.5	2.57±1.45	3.15±1	2.57±1.05	0.27±0.52	0.17±0.38	1±1.1	0.63±1
	1	2	3	4	5	6	7	8	9
	Species								
1	*Cornus sanguinea*	73.3	33.3	76.7	100	0	0	6.7	6.7
2	*Prunus spinosa*	33.3	46.7	80	36.7	0	0	6.7	3.3
3	*Euonymus verrucosa*	40	26.7	70	36.7	0	0	0	0
4	*Corylus avellana*	30	23.3	40	40	0	0	3.3	0
5	*Carpinus betulus*	23.3	40	0	6.7	0	0	6.7	0
6	*Rosa canina*	10	6.7	10	6.7	0	0	13.3	10
7	*Juniperus communis*	6.7	0	0	0	0	3.3	30	10
8	*Quercus robur*	10	13.3	0	13.3	0	0	0	0
9	*Ononis spinosa*	0	0	0	0	0	0	20	16.7
10	*Euonymus europaea*	10	13.3	0	6.7	0	0	0	0
11	*Frangula alnus*	16.7	6.7	3.3	0	0	0	0	3.3
12	*Crataegus monogyna*	13.3	6.7	10	0	0	0	0	0
13	*Pinus sylvestris*	0	0	0	0	0	10	6.7	6.7
14	*Tilia cordata*	10	13.3	0	0	0	0	0	0
15	*Chamaecytisus ruthenicus*	0	0	0	0	20	0	0	0
16	*Cerasus avium*	0	6.7	6.7	3.3	0	0	0	0
17	*Rhamnus cathartica*	0	6.7	6.7	0	3.3	0	0	0
18	*Viburnum opulus*	3	6.7	3.3	0	0	0	3.3	0
19	*Quercus patraea*	6.7	0	0	0	3.3	0	0	0

	1	2	3	4	5	6	7	8	9
20	*Daphne mezereum*	3.3	6.7	0	0	0	0	0	0
21	*Fraxinus excelsior*	0	0	3.3	3.3	0	0	0	0
22	*Ligustrum vulgare*	0	0	0	0	0	0	3.3	3.3
23	*Lonicera xylosteum*	0	0	0	3.3	0	0	0	0
24	*Malus sylvestris*	0	0	0	0	0	3.3	0	0
25	*Ribes sp.*	0	0	0	0	0	0	0	3.3
26	*Sambucus nigra*	0	0	3.3	0	0	0	0	0

Table 3. Density and frequency (%) of forest herbs species of "c" group growing on four patches (Ek, Ebk, M1, M2 each sized 30x1m^2). Observations in 2004, 2006 and 2007 Polana Polichno reserve

Lp.	Plots	Ebk04	Ebk06	Ek04	Ek06	M104	M107	M204	M207
	Mean number of species/m^2	15.3±4.74	16.1±2.5	10.8±2.53	9±1.86	21.6±2.73	25.9±2.22	26.7±4.45	24.9±3.0
	Mean number of „c" group species/m^2	7.1±4.46	3.7±1.62	5.16±1.55	5.17±1.67	0.27±0.45	0.93±0.25	0.03±0.18	0.8±0.89
	1	2	3	4	5	6	7	8	9
1	Species *Cruciata glabra*	90	83.3	10	0	26.7	93.3	3.3	13.3
2	*Viola reichenbachiana*	70	80	53.3	63.3	0	0	0	0
3	*Lathyrus vernus*	60	23.3	83.3	76.7	0	0	0	3.3
4	*Pulmonaria obscura*	73.3	46.7	53.3	50	0	0	0	0
5	*Viola mirabilis*	76.7	46.7	16.7	73.3	0	0	0	0
6	*Asarum europaeum*	40	6.7	56.7	73.3	0	0	0	0
7	*Convallaria maialis*	90	23.3	53.3	10	0	0	0	0
8	*Galium odoratum*	6.7	0	43.3	66.7	0	0	0	43.3

	1	2	3	4	5	6	7	8	9
9	*Aegopodium podagraria*	70	10	63.3	0	0	0	0	0
10	*Anemone nemorosa*	23.3	0	43.3	46.7	0	0	0	0
11	*Melica nutans*	30	0	0	16.7	0	0	0	0
12	*Carex montana*	6.7	23.3	0	3.3	0	0	0	0
13	*Fragaria vesca*	13.3	0	0	0	0	0	0	16.7
14	*Chaerophyllum aromaticum*	6.7	16.7	0	0	0	0	0	0
15	*Galium schultesii*	13.3	0	10	0	0	0	0	0
16	*Ranunculus cassubicus*	13.3	0	6.7	3.3	0	0	0	0
17	*Milium effusum*	0	0	3.3	13.3	0	0	0	0
18	*Geum urbanum*	3.3	6.7	6.7	0	0	0	0	0
19	*Lilium martagon*	0	0	3.3	10	0	0	0	0
20	***Cephalanthera damasonium***	**3.3**	**3.3**	**0**	**6.7**	**0**	**0**	**0**	**0**
21	*Sanicula europaea*	6.7	0	0	3.3	0	0	0	0
22	*Poa nemoralis*	6.7	0	0	0	0	0	0	0
23	*Maianthemum bifolium*	3.3	0	3.3	0	0	0	0	0
24	*Brachypodium sylvaticum*	0	0	3.3	0	0	0	0	0
25	*Glechoma hederacea*	0	0	0	0	0	0	0	3.3
26	*Moechringia trinervia*	0	0	3.3	0	0	0	0	0

Table 4. Density and frequency (%) of synanthropic and meadow species of "d" group growing on four patches (Ek, Ebk, M1, M2 each sized 30x1m2). Observation in 2004, 2006 and 2007 Polana Polichno reserve

Lp.	Plots	Ebk04	Ebk06	Ek04	Ek06	M104	M107	M204	M207
	Mean number of species/m^2	15.3±4.74	16.1±2.5	10.8±2.53	9±1.86	21.6±2.73	25.9±2.22	26.7±4.45	24.9±3.0
	Mean number of „d" group species/m^2	1.27±0.94	1.87±0.78	1.03±0.81	0.27±0.52	2.7±0.95	5.03±1.65	4.67±1.45	5.17±1.67
	1	2	3	4	5	6	7	8	9
1	Species *Veronica chamaedrys*	23.3	60	0	0	73.3	76.7	60	56.7
2	*Coronilla varia*	6.7	16.7	0	0	40	40	100	73.3
3	*Festuca ovina*	0	0	3.3	0	86.7	0	96.7	0
4	*Knautia arvensis*	0	3.3	0	0	60	30	43.3	46.7
5	*Briza media*	0	0	0	0	10	13.3	33.3	80
6	*Euphorbia esula*	0	0	0	0	6.7	66.7	23.3	16.7
7	*Galium aparine*	30	6.7	60	16.7	0	0	0	0
8	*Elymus repens*	0	73.3	0	0	13.3	16.7	6.7	0
9	*Vicia cracca*	13.3	0	3.3	0	10	13.3	70	0
10	*Achillea millefolium*	0	0	0	0	0	33.3	0	53.3
11	*Medicago lupulina*	0	0	0	0	0	46.7	0	36.7
12	*Cuscuta epithymum*	0	0	0	0	46.7	20	0	10
13	*Poa pratensis*	0	0	0	0	13.3	0	13.3	33.3
14	*Poa angustifolia*	0	0	0	0	0	56.7	0	0
15	*Linaria vulgaris*	0	0	0	0	6.7	23.3	6.7	16.7
16	*Polygala vulgaris*	0	0	0	0	3.3	23.3	0	20
17	*Trifolium pratense*	0	0	0	0	0	23.3	0	20
18	*Carex spicata*	26.7	0	6.7	0	0	0	0	0
19	*Pimpinella saxifraga*	10	6.7	0	0	3.3	0	0	13.3

	1	2	3	4	5	6	7	8	9
20	*Fallopia convolvulus*	0	0	13.3	0	0	16.7	0	0
21	*Astragalus glycyphyllos*	3.3	16.7	6.7	0	0	0	0	0
22	*Centaurea jacea*	0	0	0	0	0	0	6.7	13.3
23	*Falcaria vulgaris*	0	0	0	0	0	0	3.3	10
24	*Cirsium arvense*	0	0	3.3	0	0	0	0	6.7
25	*Clinopodium vulgare*	10	0	0	0	0	0	0	0
26	*Taraxacum officinale*	0	0	3.3	6.7	0	0	0	0
27	*Trifolium repens*	0	0	0	0	0	0	0	6.7
28	*Galeopsis pubescens*	0	3.3	3.3	0	0	0	0	0
29	*Dactylis glomerata*	3.3	0	0	0	0	0	3.3	0
30	*Ranunculus repens*	0	0	0	0	0	0	0	3.3
31	*Senecio jacobea*	0	0	0	0	0	3.3	0	0
32	*Sonchus arvensis*	0	0	0	3.3	0	0	0	0