VEGETATION DYNAMICS ON FALLOW AGRICULTURAL AREAS IN PRZEMYŚL FOOTHILLS (SOUTHEASTERN POLAND)

BEATA BARABASZ-KRASNY

Institute of Biology,
Departament of Botany, Pedagogical University
Podbrzezie 3, 31-054 Kraków, Poland
e-mail: bbk_ap@vp.pl

(Received: May 18, 2004. Accepted: December 12, 2004)

ABSTRACT

The studies of fallow lands were undertaken on the Przemyśl hills in the area of Cisowa locality which, till very recently, have been owned by a State Farm (PGR). The objective was to gain insight into the composition and diversification of plant communities on meadows, pastures and fields laid fallow, in context of habitat conditions prevailing after the use had ceased. The study utilised an old cadastral map showing the type of communities by category of use: meadows, pasture, and cultivated fields. The study material consisted of 180 relevés, obtained in the period 1998-2000 using the Braun-Blanquet method. By employing numerical classification, eight plant communities were distinguished, including only two of the association rank: Epilobio-Juncetum effusi, Arrhenatheretum elatioris. The analysis of Ellenberg's habitat indices proved that all the communities belonged to the half-light vegetation group, occurring mostly on fresh soils, under intermediate moisture-content conditions, more rarely on moist soils which do not dry out. The soil reaction was most often neutral or slightly acidic, and in most of the soils the nitrogen content was in the intermediate range. The two principal trends in the succession of communities in the area, after its farming management has ceased, are: marked increase in species richness resulting from the expansion of species, and the process of overgrowing by woody vegetation.

KEY WORDS: succession, fallow, agricultural areas, environmental conditions, cessation of management methods.

INTRODUCTION

The privatization process of the property held by former State Farms proceeds at a very slow pace, thus the map of Poland shows numerous aggregations of farmlands once owned by state farms and now laid fallow. From the viewpoint of farm management practices, the development of large pieces of unused land is an adverse phenomenon because it allows these lands to be overgrown by forest-shrub communities (Barabasz-Krasny 2002). For scientists involved in studies of succession, however, the same fallow-land sites provide an opportunity to gather field observations on natural elements of the local flora reclaiming the sites.

The study of the fallow lands was carried out within the Przemyśl hills near Cisowa locality, on the property which has been owned by a state farm till very recently. The objective was to learn about the composition and diversification of the plant communities on fallow meadows, pastures and fields, in the context of habitat conditions prevailing after their use had ceased.

MATERIALS AND METHODS

Cisowa is a small village southwest of Przemyśl town, between Bircza and Krasiczyn localities [22°29'E; 49°40'N; the highest hill in the area is Mordownia Mt. – 479.9 m a.s.l.]. The village occupies a small portion of the large stream valley of the same name, some 2 km south of the Przemyśl – Sanok road (Fig. 1). Under the geobotanical classification system, the area belongs to the district of Wooded Carpathians (*Karpaty Lesiste*) and the sub-district of Bieszczady Niskie Mts (Zemanek 1991). The tectonic unit is skolska nappe covered with over 200 m-thick Quarternary sediments. The latter includes the Inoceram layers, and the Menilite layers underneath (Alexandrowicz 1999; Gilewska 1999). The soil cover in the study area consists of soils originating from decomposed coherent sedimentary rocks. These soils include brown soils (acidic and leached), and grey-brown podzolic soils (Wład 1996; Prusinkiewicz and Bednarek 1999). The flysh substrate of low permeability favours the formation of dense network of streams and rivers. Water erosion results in fragmentation

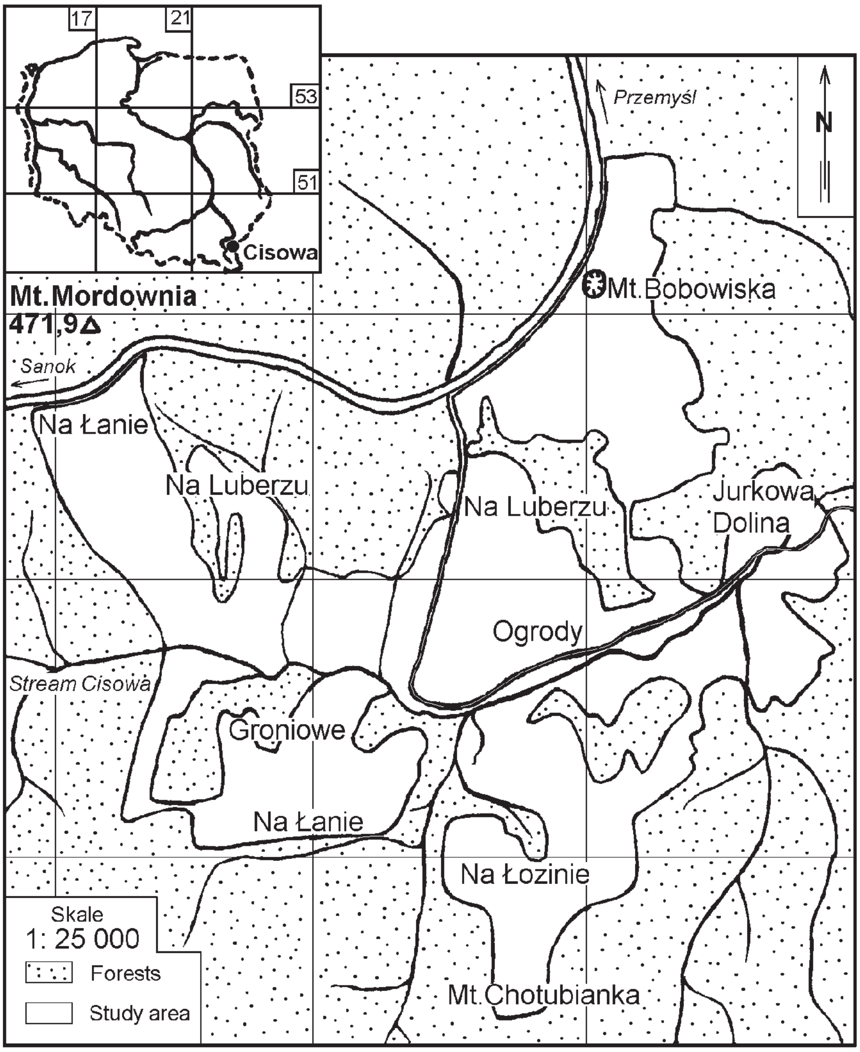

Fig. 1. Study area.

of slopes by a dense network of shallow water courses, tributaries of the Cisowa stream in the San river basin. The network of intermittent water courses is even denser (Wład 1996). The study area is located within the climatic region of the Carpathian Foreland (Niedźwiedź and Obrębska-Starkel 1991). The average values of basic climatic parameters are as follows: January temperature -3.5°C, July temperature +18°C, duration of winter – 90 days, duration of summer – 100 days, annual precipitation – 700-800 mm, number of days with snow cover – 90 (Atlas Polski 2000). The above-mentioned parameters do not take into account the local variability and thus they may deviate slightly from the values actually recorded at Cisowa.

The fallow lands under study cover a total of 316 ha, of which 282 ha are owned by the Arboretum in Bolestraszyce, Cisowa branch, while 34 ha – Jurkowa Dolina – is privately owned (Fig. 1). The whole area lies within the Przemyśl Foreland Landscape Park which was established in 1991 (Ozimek 1994).

In this study of vegetation of fallow lands, an old cadastral map was used showing the types of communities distinguished by the criterion of land use: meadows, pastures, cultivated fields (Mapa katastralna 1992). The study material consists of 180 relevés completed in the period 1998-2000 using the Braun-Blanquet method (1964). The entire set of relevés was submitted to hierarchical numerical classification (Gauch 1986). The classification was made by two methods: based on the presence/absence of species (binary scale 0, 1), and on the basis of quantitative proportions of species (according to the six-point Braun-Blanquet scale; value of 0.5 was represented as +). In the former case the Euclidean distance formula was used, in the latter – van der Marel's formula for similarity. The grouping was based on the Minimum Variance Clustering method. The classification made use of MULVA – 5 software package (Wildi and Orloci 1993). The groups of relevés representing particular types of communities were distinguished on the basis of dispersion diagram developed by comparison of both dendrograms (Dzwonko and Loster 1990) (Fig. 2). The syntaxonomical allegiance of species was determined on the basis of the following references: Medwecka-Kornaś et al. (1972), Matuszkiewicz (1984, 2001). The nomenclature of vascular plants followed Mirek et al. (2002).

In order to specify habitat conditions, the weighed means of Ellenberg's indices were calculated in relations to cover-abundance values (light – L, moisture – F, reaction – R, nitrogen content – N – Ellenberg et al. 1992), and then the

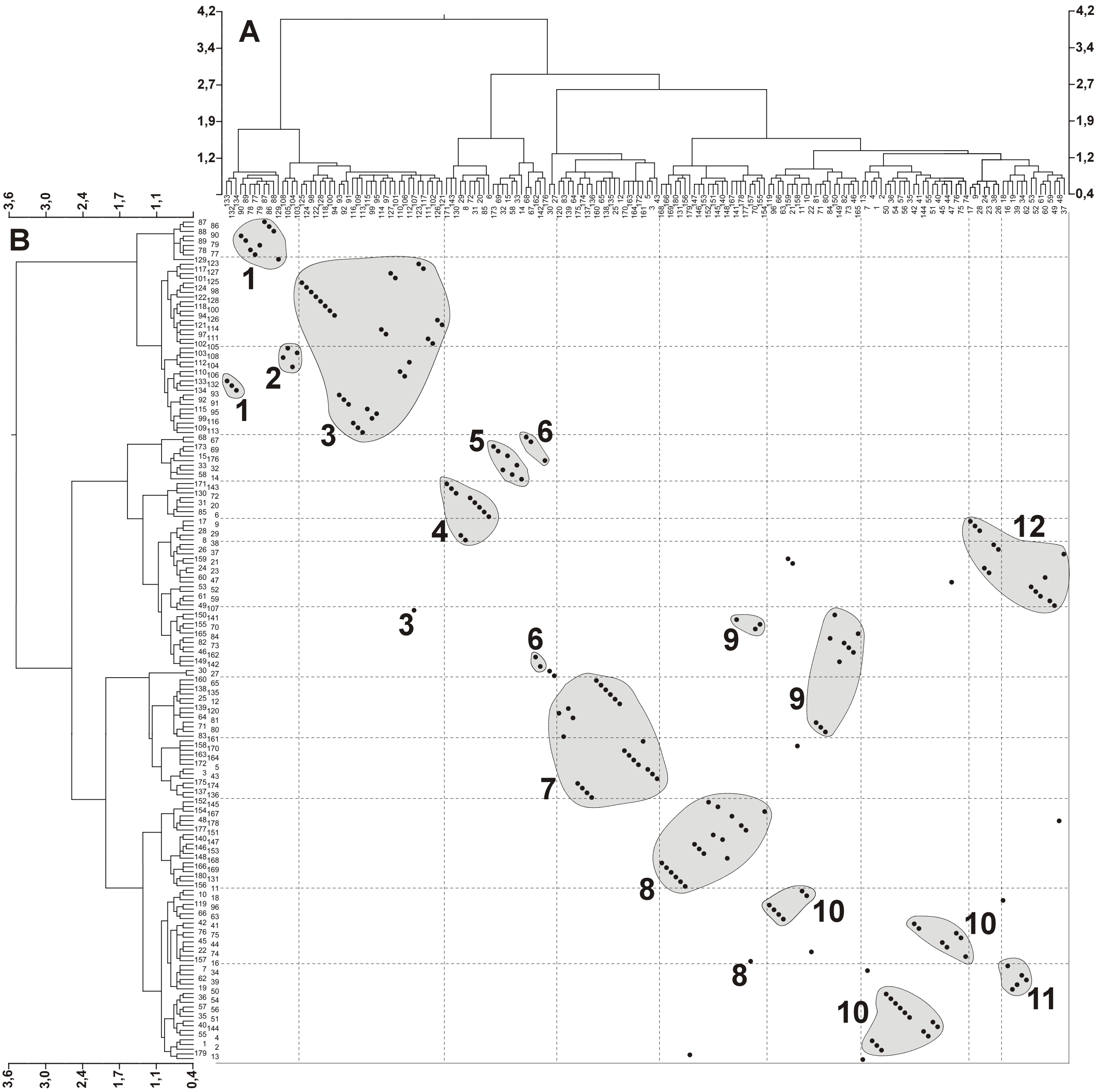

Fig. 2. Classification of the 180 phytosociological relevés from fallow meadows, pastures and fields near Cisowa. A – dendrogram basing on quantitative proportions of species (according to six-point Braun-Blanquet scale); B – dendrogram basing on on the presence/absence of species presence; relevés groups describe types of communities: 1 – community Vicia tetrasperma – Taraxacum officinale; 2 – community with dominance of *Calamagrostis epigejos*; 3 – community Hypericum perforatum – Torilis japonica; 4 – Epilobio-Juncetum effusi typical form; 5 – community with dominance of *Urtica dioica*; 6 – community with dominance of *Mentha longifolia*, 7 – Arrhenatheretum elatioris brizetosum mediae; 8 – A. e. form with Phleum pratense – Rumex crispus; 9 – A. e. form with weeds; 10 – A. e. typicum; 11 – Epilobio-Juncetum effusi dry form; 12 – community Cirsium arvense – Elymus repens-; unmarked dots stand for plots without syntaxonomic classification.

arithmetic means for the whole communities were calculated for all relevés. Detrended Correspondence Analysis – DCA method (Hill and Gauch 1980) employing CANOCO v. 3.10 (ter Braak 1987, 1990) was used for ordering relevés in accordance with potential environmental gradients. The ordering was done for the entire body of relevés and separately for the relevés pertaining to fallow meadows, pastures, and fields, using cover-abundance values for individual species. The correlations with the axes of habitat parameters were calculated using the values of Ellenberg indices as a basis.

RESULTS

Classification

The numerical classification of relevés allowed identification of 8 distinct types of communities. Out of these only 2 matches with the communities described in the previous scientific reports were found. The remaining communities were only classified into the higher syntaxonomic units – alliance, order or class. In the dendrograms most of the groups of relevés can be fairly easily distinguished although some are divided into smaller subgroups (Fig. 2). Out

TABLE 1. Average Ellenberg's indicator values calculated for communities of fallow meadows, pastures and fields in Cisowa.

Type of community	Number of relevés	Average Ellenberg's indicator values			
		Light L	Soil moisture F	Soil reaction R	Soil nitrogen **N**
Epilobio-Juncetum effusi typical form	10	6.73	**6.60**	6.59	5.60
Epilobio-Juncetum effusi dry form	5	6.85	5.90	**5.01**	4.97
Arrhenatheretum elatioris typicum	26	6.85	5.31	5.99	5.36
Arrhenatheretum elatioris brizetosum mediae	22	6.85	**4.95**	6.45	**4.40**
Arrhenatheretum elatioris form with Phleum pratense – Rumex crispus	19	6.82	5.37	5.98	5.57
Arrhenatheretum elatioris form with weeds	13	6.94	5.36	6.32	5.74
Community Cirsium arvense – Elymus repens	14	6.77	5.72	5.68	5.59
Community Hypericum perforatum – Torilis japonica	31	**6.69**	5.49	6.26	5.83
Community with dominance of *Calamagrostis epigejos*	4	6.86	5.69	6.06	5.73
Community Vicia tetrasperma – Taraxacum officinale	12	**7.00**	5.14	6.38	6.02
Community with dominance of *Urtica dioica*	7	6.84	5.83	6.89	**7.68**
Community with dominance of *Mentha longifolia*	5	6.78	6.16	**7.28**	6.53

of 180 analysed relevés only 12 deviated from the distinguished groups, thus they were excluded from further analysis as succession stages not representative for the study area.

The analyses of the index numbers according to Ellenberg have shown that all the communities belong to the half-light vegetation (L = 6.69-7.0), occurring mostly on fresh soils, under intermediate moisture conditions, moist soils which do not dry out (F = 4.95-6.60). The reaction of soils in such habitats is most often neutral or slightly acidic (R = 5.01--7.28), and in most communities the content of mineral nitrogen in the soil is at the intermediate level. In extreme cases it attains the values characteristic of soils either poor or rich in this component (N = 4.40-7.68) (Table 1).

Characterisation of main groups of plant communities:
Communities of fallow meadows

On fallow meadows, the most typical fresh hay meadow association Arrhenatheretum elatioris continues. Two subassociations (A. e. typicum, A. e. brizetosum mediae) and two forms (A. e. form with Phleum pratense – Rumex crispus and A. e. form with weeds) of this community were distinguished there.

Arrhenatheretum elatioris typicum is found on the top parts of hills and slopes of gentle inclination. Among the species characteristic of *A. e.* association and Arrhenatherion alliance, the most stable are: *Galium mollugo*, *Campanula patula* (V^{th}, IV^{th} degree of constancy). Other species occur in patches only as single individuals (*Trifolium dubium*, *Crepis biennis*, *Arrhenatherum elatius*, *Knautia arvensis*). The appearance of this phytocoenosis is determined by the species of the order Arrhenatheretalia (*Dactylis glomerata*, *Phleum pratense*, *Achillea millefolium*) and of the class Molinio-Arrhenatheretea (*Festuca rubra*, *Veronica chamaedrys*, *Agrostis capillaris*, *Holcus lanatus*) – V^{th} degree of constancy. The number of species per relevé varied from 28 to 57.

Arrhenatheretum elatioris brizetosum mediae occurs on slopes exposed to S, S-W, N-W, W. The differential species are: *Clinopodium vulgare*, *Pimpinella saxifraga*, *Origanum vulgare*, and *Briza media* to a lesser extent. The composition of this meadow is marked by the evident presence of species typical of thermophilous grasslands of Festuco-Brometea (*Agrimonia eupatoria*, *Filipendula vulgaris*, *Allium oleraceum*, *Euphorbia cyparissias*, *Plantago media*, *Centaurea scabiosa* etc.). Apart from these, a large group of species characteristic of the association A. e., alliance Arrhenatherion, order Arrhenatheretalia and the class Molinio-Arrhenatheretea occur. In terms of species composition, this community is the richest one in the study area – from 46 to 78 species per relevé.

The patches Arrhenatheretum elatioris, form with *Phleum pratense – Rumex crispus* occur on slopes with N-E, or N-W exposure, more rarely with E or S-E exposures. *Phleum* and *Rumex* (V^{th} degree of constancy), are differential species, accompanied by: *Dactylis glomerata*, *Achillea millefolium*, *Taraxacum officinale*, *Agrostis capillaris*, and other. In the patches there are also large proportions of species of the order Arrhenatheretalia and the class Molinio-Arrhenatheretea, whereas there are only 4 species of the alliance Arrhenatherion, which, with evident presence of taxa of the classes Artemisietea and Plantaginetea, is a sign of certain neglect in farming practices. The number of species per relevé varies from 27 to 52.

Arrhenatheretum elatioris, in the form infested with weeds, occurs in lower portions of slopes exposed towards S, S-E, E, and more rarely, exposed towards N and N-W. The differential species in this community are weeds, such as: *Cirsium arvense*, *Elymus repens*, *Rumex crispus* (V^{th} degree of constancy). Also numerous are species of the class Molinio-Arrhenatheretea (*Agrostis capillaris*, *Lathyrus pratensis*, *Veronica chamaedrys*, *Festuca rubra*, *F. pratensis* – V^{th} degree of constancy). The proportions of taxa characteristic of the association, alliance and order is lower, but nevertheless allow classifying it to some lower units. However, the presence of weeds is evident, particularly of the class Plantaginetea (*Ranunculus repens*, *Potentilla anserina*, *P. reptans*, *Carex hirta* – IV^{th} and III^{rd} degree of constancy). The number of species per relevé varies from 23 to 63.

In the bottom of the valley, in moist places, often in depressions, there are patches of the community with dominance of *Mentha longifolia*. The proportion of species from fresh meadows is fairly low. Usually they can be found only on edges of the patches. Apart from *Mentha*, *Chaerophyllum aromaticum* occurs in fairly high numbers, as well as the species of the classes Plantaginetea and Artemisietea (*Ranunculus repens*, *Cirsium arvense*, *Urtica dioica*). Finally, the community could be classified as belonging to the class Plantaginetea. The number of species in relevés is low and ranges from 20 to 31.

Communities of fallow pastures

On fallow pastures, in places overlaying a low-permeability substrate, where grazing has been once very intensive, the association *Epilobio-Juncetum effusi* occurs, in typical and dried-up forms. In the typical form, E.-J. e. is characterised by the presence of hygrophilous species from the alliance Calthion (*Juncus effusus*, *Myosotis palustris*, *Equisetum palustre*, *Scirpus silvaticus*, *Lythrum salicaria*, *Trifolium hybridum* – from Vth to IInd degree of constancy), and by fairly high proportions of the species from Plantaginetea and Artemistietea classes. The number of species per relevé varies from 17 to 49. In the dried-up form of E.-J. e., rushes predominate – *Juncus effusus*, *J. tenuis*, *J. conglomeratus*. The species of the alliance Calthion, except *Juncus effusus* and *Trifolium hybridum*, occur only as single individuals, whereas the species from the order Arrhenatheretalia, typical to fresh meadows, occur in high proportions. The number of species per relevé varies from 39 to 57. Both forms of E.-J. e. were classified into the alliance Calthion and the order Molinietalia.

In lower portions of the valley where sheep were brought to farms to be kept there at night, there are patches of the community with *Urtica dioica* as the dominant species. The presence of expansive dominant species results in very low numbers of species per relevé: only between 13 and 27, which is the lowest number in all phytocoenoses identified in the study area. The community was classified in the class Artemisietea, but its allegiance to lower syntaxonomic units could not be determined.

The Cirsium arvense-Elymus repens community was also found on old pastures and a fallow meadow of the complex "Groniowe". The appearance of the community is determined by dense masses of *Cirsium* and *Elymus*, accompanied by: *Agrostis capillaris*, *Dactylis glomerata*, *Deschampsia caespitosa*, *Festuca rubra* oraz *Holcus lanatus* (Vth and IVth degree of constancy). The community belongs to the order Arrhenatheretalia and the class Molinio-Arrhenatheretea, although the marked presence of ruderal species of the classes Plantaginetea, Artemisietea, and even Epilobietea. The number of species per relevé varies from 17 to 52.

Communities of fallow fields

On fallow fields, mostly within the "Bobowiska" mountain area, a transitional community appeared, with *Hypericum perforatum – Torilis japonica*. Apart from *Hypericum* and *Torilis* in the herbaceous layer *Agrostis capillaris*, *Cirsium arvense*, *Urtica dioica*, *Eupatorium cannabinum*, *Vicia tetrasperma*, *Equisetum arvense* and other dominate (Vth degree of constancy). The composition of this community represents a mixture of species from the classes Artemisietea, Plantaginetea, Secalietea and Molinio-Arrhenatheretea. The occurrence of a large group of species of the class Molinio-Arrhenatheretea, order Arrhenatheretalia and the alliance Arrhenatherion indicates that it is a succession stage of fresh meadow, emerging as a result of discontinuation of cultivation.

Phytocoenoses with the domination of *Calamagrostis epigejos* occur within former fields of "Bobowisko" hill. The physiognomy of the community is determined by compact masses of *Calamagrostis*, accompanied by admixtures of *Cirsium arvense, Equisetum arvense*, *Euphorbia cyparissias*. Other species occur as single individuals, mostly along the edges of patches. Because of the low number of characteristic species, the community has been classified into the class Molinio-Arrhenatheretea, without identifying lower syntaxonomic units. The patches with certain proportions of *Calamagrostis epigejos* are fairly common, but their composition is so unstable that they do not represent any single type of community.

In the vicinity of the village, on the slope of the low hill called "Ogrody" field complex, the community Vicia tetrasperma – Taraxacum officinale occurs. Apart from *Vicia* and *Taraxacum*, *Phleum pratense* is another differential species. As indicated by the high proportion of cover in the patches, *Phleum* has been probably sown there on purpose, after the cultivation discontinued. The presence of a group of species from the classes Chenopodietea, Secalietea, Artemisietea and Plantaginetea is a vestige of former cultivation. However, their cover in the patches and constancy are relatively low. On the other hand, the species of the class Molinio-Arrhenatheretea, order Arrhenatheretalia and the alliance Arrhenatheretalia appear in high proportions in the herbaceous layer.

Ordination

The ordination of all relevés produces an arrangement of communities from the most moist being at the same time nitrophilous (left upper part of the diagram) to the driest and the most nitrophobous (right lower part of the diagram) (Fig. 3). The group of intermediately moist nitrophytes includes the community with domination of *Urtica dioica*, and most moist communities include Epilobio-Juncetum effusi – typical form and the community with domination of *Mentha longifolia*. The driest and, at same time, nitrophobous communities include Arrhenatheretum elatioris brizetosum mediae, showing affinity towards xerothermic grasslands – also very poor in soil nitrogen. Also the number of species per relevé shows a high positive correlation

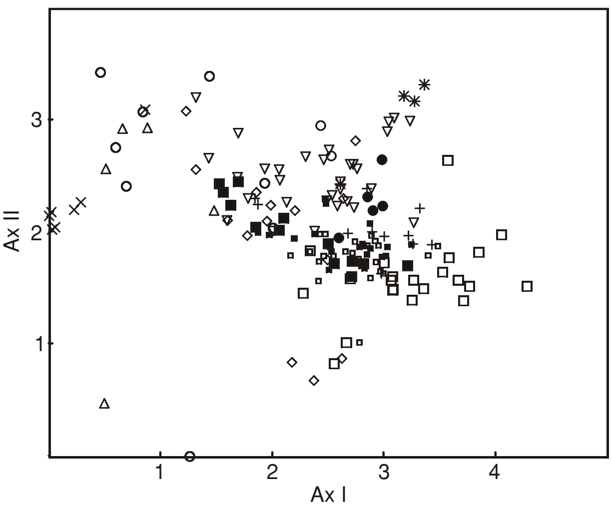

Fig. 3. Ordination of all fallow area relevés along the first two DCA axes according to species quantities: ❍ – Epilobio-Juncetum effusi typical form, ● – E.-J. e. dry form, □ – Arrhenatheretum elatioris typicum, ☐ – A. e. brizetosum mediae, ■ – A. e. form with Phleum pratense – Rumex crispus, ■ – A. e. form with weeds, ◊ – community Cirsium arvense – Elymus repens, ▽ – community Hypericum perforatum – Torilis japonica, ✳ – community with dominance of *Calamagrostis epigejos*, + – community Vicia tetrasperma – Taraxacum officinale, × – community with dominance of *Urtica dioica*, △ – community with dominance of *Mentha longifolia*.

TABLE 2. Correlations between DCA axes and some characteristics of fallow meadows, pastures, and fields in Cisowa.

Characteristics	Meadows		Pastures		Fields		All	
	Axis I	Axis II	Axis I	Axis II	Axis I	Axis II	Axis I	Axis II
Herbaceous cover	0.29	0.31	-0.20	-0.22	0.14	-0.46	-0.23	-0.06
Maximum height of herbs	0.43	-0.07	-0.03	-0.05	0.42	-0.06	-0.32	-0.04
Bryophyta cover	-0.35	-0.30	**0.72**	0.09	0.10	0.49	0.30	0.21
Shrubs and trees cover	-0.33	0.32	-	-	0.34	0.05	0.17	0.18
Number of species in relevé	**-0.70**	0.17	**0.79**	-0.06	0.19	0.12	**0.65**	-0.14
Ellenberg indicator values:								
Light L	-0.08	0.33	-0.04	0.11	-0.45	-0.18	0.18	-0.19
Soil moisture F	**0.65**	-0.39	0.26	**-0.68**	**0.75**	0.18	**-0.58**	0.45
Soil reaction R	0.42	**0.64**	**-0.53**	-0.38	-0.07	**-0.68**	-0.35	0.04
Soil nitrogen N	**0.75**	-0.34	**-0.89**	-0.15	-0.16	**-0.51**	**-0.71**	0.38

with the Ist DCA axis, thus differentiating all the communities in this respect. The most species-rich are patches of A. e. brizetosum mediae (the right side of the diagram) while the poorest in this respect is the community with predominance of *Urtica dioica* (left side of the diagram). In this case, the IInd DCA axis does not show any significant direction of variability (Table 2).

A separate ordering of relevés from fallow meadows showed that the factors responsible for the highest diversification of communities are: the nitrogen content in soils, and – to a lesser extent – moisture content (positive correlation with the Ist DCA axis) as well as soil reaction (positive correlation with the IInd DCA axis) (Table 2). Among the moistest communities, most nitrophilous and least rich in species (negative correlation with the Ist DCA axis), were the following communities: patches with the domination of *Mentha longifolia* and some patches Arrhenatheretum elatioris, form infested with weeds (right central part of the diagram). Almost all patches of A. e. brizetosum mediae are the driest, nitrophobous and richest in species (left upper part of the diagram). On the other hand, most of A. e. the form with Phleum pratense – Rumex crispus, as well as A. e. typicum (left lower part of the diagram) (Fig. 4A) can be placed among the patches of the lowest soil reaction and fairly low nitrogen content.

Ordering of relevés from fallow pastures showed the following factors as responsible for the diversification of communities: nitrogen content as a principal factor, and, to a lesser extent, soil reaction (strong negative correlation with the Ist DCA axis) and moisture content (strong negative correlation with the IInd DCA axis) (Table 2). Among the most nitrophilous, intermediately moist and poor in terms of the number of species (also devoid of moss layer – positive correlation with the Ist DCA axis), the patches with the domination of *Urtica dioica* (left central part of the diagram) stand out. On the other hand, among the moistest communities, low on soil nitrogen but, at the same time, relatively rich in species (including bryophytes) are some patches of Epilobio-Juncetum effusi in typical and dried-up forms (right central part of the diagram) (Fig. 4B). Compared with other communities on former pastures, the patches of the community Cirsium arvense – Elymus repens are driest and fairly low on soil nitrogen (upper central part of the diagram).

In the case of ordering relevés from fallow fields, the analysis points at moisture content as the factor responsible for the diversification of communities (strong positive correlation with the Ist DCA axis, and – to a lesser extent – at the reaction and nitrogen content in soil (negative correlations with the IInd DCA axis) (Table 2). In fields, almost all patches studied are mostly characterised by weakly acid reaction and intermediate content of soil nitrogen, except some which represent the community Hypericum perforatum – Torilis japonica (lower part of the diagram). The community with the domination of *Calamagrostis epigejos* (right side of the diagram) is the moistest, whereas the community Vicia tetrasperma – Taraxacum officinale is the driest (left side of the diagram). Other variables in these communities do not manifest significant correlations with DCA axes (Fig. 4C).

DISCUSSION

The increase of species diversity in early stages of succession is a known phenomenon observed by many researchers of secondary succession in various climatic zones (Peet 1978; Campbell and van der Meulen 1980; Falinska 1989a, b; Dzwonko and Loster 1990; Falińska 1991). The highest species diversity in the non-forest sites being overgrown occurs when heliophilous and heliphobous species appear side by side in the same patches (Bazzaz 1975). In the studied fallow lands of Cisowa, almost all communities show high diversity and complex combinations of species. For example, in the fallow fields, after six years after the discontinuation of agricultural use, the most numerous are still meadow species of the class Molinio-Arrhenatheretea. Still persisting, however, are the segetal weeds of the older cultivated fields (of the classes Secalietea, Chenopodietea, Plantaginetea, Artemisietea) and an additional group of tree and shrub species penetrating into the sites. The ultimate result of the overlapping floristic alterations is a high level of species richness. The differences in the floristic compositions of fallowed fields result not only from the various farming practices once applied there, but, above all, from the diversity in habitat conditions, chiefly in moisture content which was shown in this study to be the factor differentiating the floristic composition in this case (Table 2, Figs 4C, 5). Another essential element to be considered is the exact age of the fallow fields whose importance has been highlighted in many reports (Dubiel 1984; Falińska 1991), but here have been no accurate records about it maintained in Cisowa. It is only known that in the early 1990s these areas were cultivated fields (Mapa katastralna 1992).

The phytocoenoses Arrhenatheretum elatioris provide the best examples of high species diversity on fallow mea-

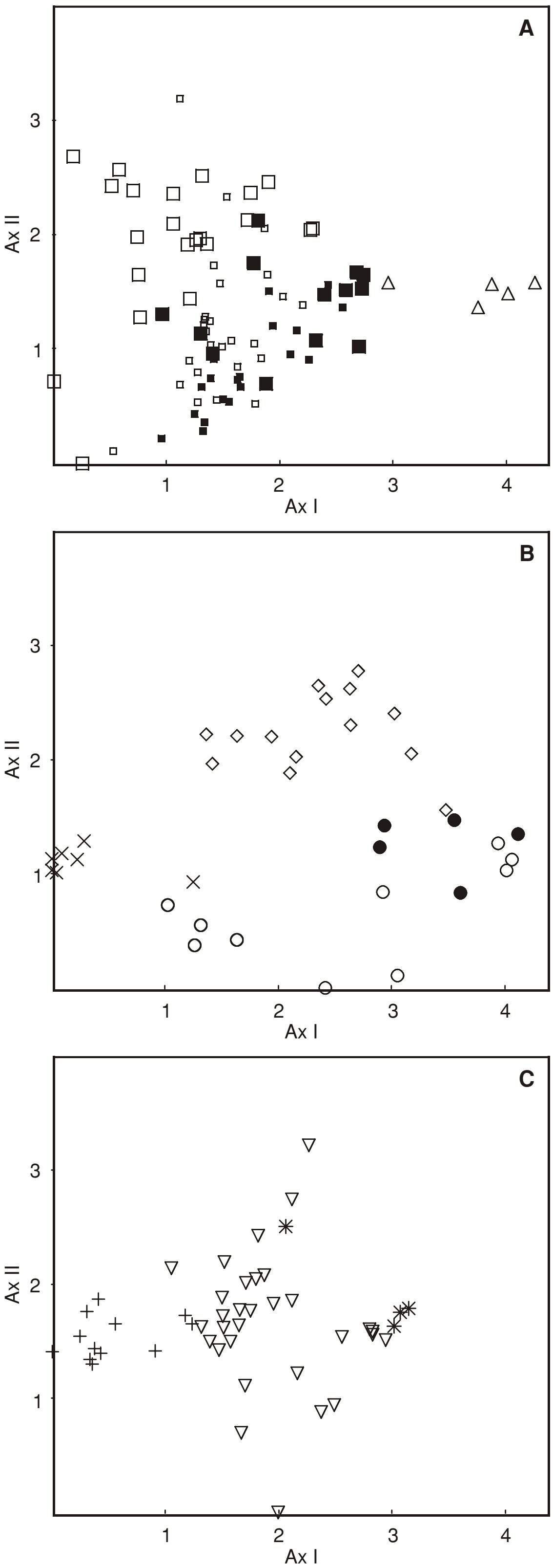

Fig. 4. Ordination of fallow area relevés separately for meadows (A), pastures (B) and fields (C) along the first two DCA axes according to species quantities: ❍ – Epilobio-Juncetum effusi typical form, ● – E.-J. e. dry form, □ – Arrhenatheretum elatioris typicum, ☐ – A. e. brizetosum mediae, ■ – A. e. form with Phleum pratense – Rumex crispus, ■ – A. e. form with weeds, ◊ – community Cirsium arvense – Elymus repens, ▽ – community Hypericum perforatum – Torilis japonica, ✳ – community with dominance of *Calamagrostis epigejos*, + – community Vicia tetrasperma – Taraxacum officinale, × – community with dominance of *Urtica dioica*, △ – community with dominance of *Mentha longifolia*.

dows of Cisowa. The number of species specified in the tables of the forms and sub-associations identified in this community ranges from 121 (A. e. form infested with weeds) to 217 (A. e. brizetosum mediae). Even A. e. typicum occurring in the study area deviates in terms of its high species richness from phytocoenoses described in relevant publications (Dubiel 1987; Kornaś and Dubiel 1991; Dubiel et al. 1999). The components of the herbaceous layer of A. e. include the species characteristic to typical fresh meadows as well as ruderal, shrub or even thermophilous grassland species. For example, A. e. brizetosum mediae developed on intensively insolated slopes. It is just there where the species of Festuco-Brometea thermophilous grasslands grow, which prefer dry sites with low soil nitrogen content (Table 1, Figs 3, 4A). Nevertheless, the high proportions of taxa of the class Molinio-Arrhenatheretea decides that it is a fresh meadow sub-association. Similarly as in the fallow fields, also in this case, the different nature of habitat conditions (chiefly of soil nitrogen availability and moisture content), as well as different history of farming management resulted in the diversification of the floristic compositions of the fresh meadows, after their farming use discontinued (Fig. 5).

In terms of floristics, however, not all phytocoenoses of fallow lands in the Cisowa area are rich. The communities with *Urtica dioica* and *Mentha longifolia* domination are such examples. The patches of these phytocenoses consist of nitrophilous species which prefer fertile habitats (community with *Urtica dioica*: N = 7.68; community with *Mentha longifolia*: N = 6.53 – Table 1). It is very likely that the se communities emerged as a result of discontinuation of agricultural practices. Leaving uncut or ungrazed biomass supports their decomposition on meadows and enriches the soil with nitrogen. Ultimately, the effects are the same as of applying high levels of nitrogen fertilizers (Kornaś and Dubiel 1991; Barabasz 1994, 2002). Too high levels of nutrient content in the substrate has very adverse effects on the overall species richness (Oomes et al. 1981; Berendse et al. 1992; Wilson 1994). In the table for the community with the domination of *Urtica dioica* mere 51 species were recorded, and in the table for the community with the domination of *Mentha longifolia* – 63 species. In both cases, the presence in the herbaceous layer of a single very expansive dominant species, which restricts the growth of other species, is not without significance (Michalik 1990; Falińska 1991).

The reduction in species richness of the pasture communities could be a result of overexploitation or lack of appropriate fertilisation. Affected by intensive defoliation and trampling, the proportion of tall species is reduced in favour of low, rosette-shaped species. After a certain period of time a gradual elimination of low-growing species follows (Noy-Meir et al. 1989). It is often, that intensive grazing management results in mechanical damage to the soil surface structure and – if coinciding with high levels of ground water – can convert into bog-type sites. In Cisowa, this type of processes facilitated the appearance of the Epilobio-Juncetum effusi phytocoenoses (Fig. 5). After grazing discontinued, some patches have dried up and this, in turn, enabled penetration by species of fresh meadows. As a result, a dry form of E.-J. e. community emerged which can be deemed a form of pasture in the course of regeneration. The occurrence of rushes there is still evident, because they

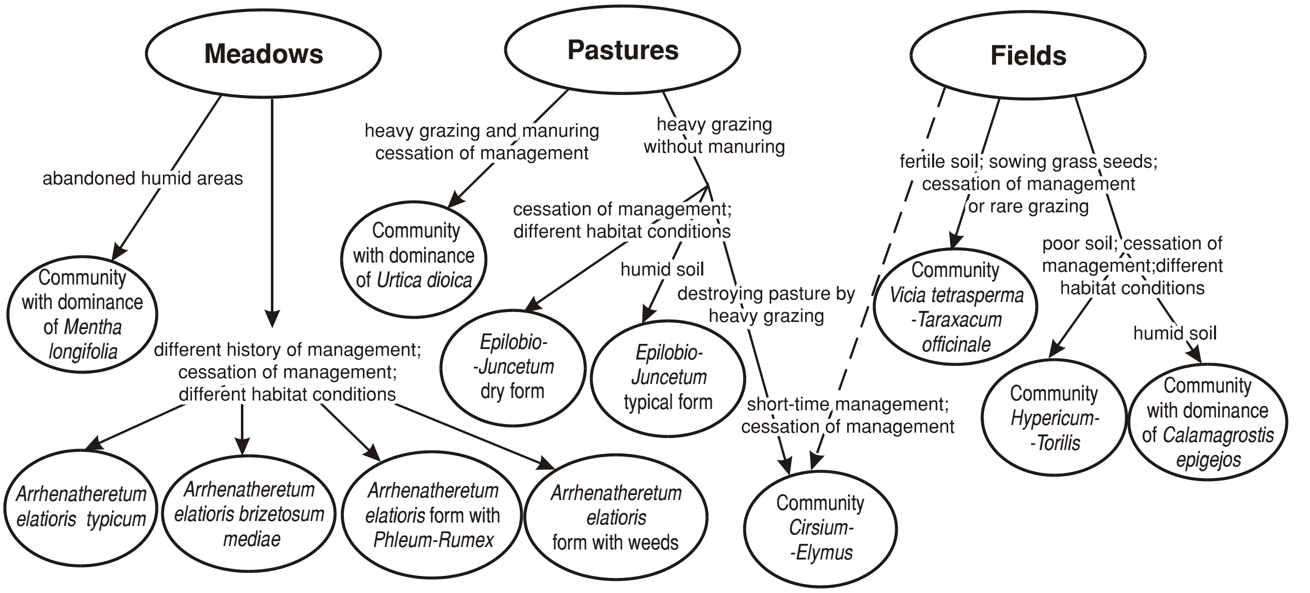

Fig. 5. Diagram of diversification of the plant communities on fallow meadows, pastures and fields near Cisowa.

can persist in the herbaceous layer owing to the growth of rhizomes and the durability of seeds in the soil for up to 60 years (Thompson et al. 1997). The gradual elimination of rushes would probably improved the species richness of this community as would do a moderate level of fertilising. Slowing down the rate of penetration of fresh meadows species into the dry form of E.-J. e. could also result from acidification of the substrate – R = 5.01 (Table 1). The latter process exerts fairly adverse effects in the soil composition and structure, and inhibits the growth of beneficial flora of soil micro-organisms (Kern 1989).

As the fallow lands of Cisowa area directly adjoins forest lands, the phenomenon of penetration by tree and shrub species is widespread in almost all communities identified throughout the study area. However, it is not before the phanerophytes appear in the shrub layer (b) that the beginning of the forest/shrub stage can be indicated. In the study area such situation prevails in five communities (community with domination of *Calamagrostis epigejos*, community Hypericum perforatum-Torilis japonica, Arrhenatheretum elatioris typicum, A. e. brizetosum mediae, A. e. form with Phleum pratense-Rumex crispus). The phanerophytes found most often include: *Salix capraea*, *Alnus incana*, *Carpinus betulus*, *Pinus sylvestris* and other. These are species dispersing via anemochory. According to Faliński (1986), they can be regarded as the first, pioneer generation of woody plants. Their establishment can only be regarded permanent when they start to produce diaspores and the efficiency of seeding is high enough to produce the second generation of theses pioneers. With a few exceptions, the individuals found are barren which corroborates the initial nature of the succession in progress. Detailed observations on the rate of penetration by phanerophytes into non-forest land were made by Michalik (1990). He found that in compact phytocoenoses, such as, for example nettle patches or other groupings of nitrophytes, penetration by woody species is very slow because seedlings have access to light cut by the species growing in compact layers. This is a perfect explanation why in such biocoenoses as the community with domination of *Urtica dioica*, or the community with domination of *Mentha longifolia* lack tree species.

In conclusion, it must be noted that the unique insight into the course of succession gained in the study of fallow land communities should encourage further projects combining modern numerical methods with a solid analysis of plant communities.

ACKNOWLEDGMENTS

I wish to thank Professor Eugeniusz Dubiel (Institute of Botany, Jagiellonian University) for patience and help in syntaxonomic assessments. At the same time I wish to thank everybody whose efforts contributed to the creation of this work in any way.

LITERATURE CITED

ALEXANDROWICZ S.W. 1999. Budowa geologiczna. In: L. Starkel (ed.), Geografia Polski – Środowisko Przyrodnicze, pp. 221-243. Państwowe Wydawnictwo Naukowe, Warszawa (in Polish).

Atlas Polski. Encyklopedia geograficzna świata. 2000. Z. Otałęga (ed). 11: 42-44. Opres, Kraków (in Polish).

BARABASZ B. 1994. Wpływ modyfikacji tradycyjnych sposobów gospodarowania na przemiany roślinności łąk z klasy Molinio-Arrhenatheretea [The effect of traditional management methods modifications on changes in meadows of Molinio-Arrhenatheretea class]. Wiad. Bot. 38 (1-2): 85-94. (in Polish with English summary)

BARABASZ-KRASNY B. 2002. Changes of the vegetation in the meadows of the northern part of the Niepołomice Forest in the course of twenty years. Ecol. Quest. 2: 131-140.

BAZZAZ F.A. 1975. Plant species diversity in old field successional ecosystems in Southern Illinois. Ecology 56: 485-488.

BERENDS E., OOMES M.J.M., ALTENA H.J., ELBERSE W.T. 1992. Experiments on the restoration of species-rich meadows in the Netherlands. Biol. Conserv. 62: 59-65.

BRAUN-BLANQUET J. 1964. Pflazensoziologie. Speringer Verlag. Wien.

CAMPBELL B.M., VAN DER MEULEN F. 1980. Patterns of plant species diversity in fynbos vegetation, South Africa. Vegetatio 43: 43-47.

DUBIEL E. 1984. Dolina Wierzbanówki: 5. Rozwój roślinności na odłogach [The Wierzbanówka Valley: 5. Succession of vegetation on abandoned fields]. Zesz. Nauk. Uniw. Jagiell. Prace Bot. 12: 97-112. (in Polish with English summary)

DUBIEL E. 1987. Dolina Wierzbanówki: 10. Zbiorowiska łąkowe [The Wierzbanówka Valley: 10. Meadow communities]. Zesz. Nauk. Uniw. Jagiell. Prace Bot. 14: 51-86. (in Polish with English summary)

DUBIEL E., STACHURSKA A., GAWROŃSKI S. 1999. Nieleśne zbiorowiska roślinne Magurskiego Parku Narodowego (Beskid Niski) [Non-forest plant communities in the Magura National Park (Beskid Niski Mts.)]. Prace Bot. Uniw. Jagiell. 33: 1-60. (in Polish with English summary)

DZWONKO Z., LOSTER S. 1990. Vegetation differentiation and secondary succession on limestone hill in southern Poland. J. Veg. Sci. 1: 615-622.

ELLENBERG H., WEBER H., DULL R., WIRTH V., WERNER W., PAULISSEN D. 1992. Zeigerverte von Pflanzen in Mitteleuropa. Scripta Geobot. 18: 1-258.

FALIŃSKI B. 1986. Sukcesja roślinności na użytkach porolnych jako przejaw dynamiki ekosystemu wyzwolonego spod długotrwałej presji antropogenicznej. Cz. I. Podstawy teoretyczne i prezentacja wybranej serii sukcesji wtórnej [Vegetation succession on abandoned farmland as a dynamics manifestation of ecosystem liberal of long continuance anthropopression]. Wiad. Bot. 30 (1): 25-50. (in Polish with English summary)

FALIŃSKA K. 1989a. Plant population processes in the course of forest succession in abondaned meadows. I. Variability and diversity of floristic compositions, and biological mechanisms of species turnover. Acta Soc. Bot. Pol. 58 (3): 439-465.

FALIŃSKA K. 1989b. Plant population processes in the course of forest succession in abondaned meadows. II. Demography of succession promotors. Acta Soc. Bot. Pol. 58 (3): 467-491.

FALIŃSKA K. 1991. Sukcesja jako efekt procesów demograficznych roślin [Succession as an effect of plant demographic processes]. In: J.B. Faliński (ed.), Dynamika roślinności i populacji roślinnych [Vegetation and plant populations dynamics]. Phytocoenosis 3 (N.S.) Sem. Geobot. 1: 43-67. (in Polish with English summary)

GAUCH H.G. 1986. Multivariate analysis in community ecology. ss. X + 298. Cambridge University Press, Cambridge.

GILEWSKA S. 1999. Rzeźba. In: L. Starkel (ed.), Geografia Polski – Środowisko Przyrodnicze, pp. 243-288. Państwowe Wydawnictwo Naukowe, Warszawa. (in Polish)

HILL M.O., GAUCH H.G. 1980. Detrended correspondence analysis, an improved ordination technique. Vegetatio 42: 47-58.

KERN H. 1989. Występowanie gleb piaskowych jako siedlisk chwastów segetalnych [Occurrence of the poorest sandy soils as the agroecosystems of segetal weeds communities]. Zesz. Nauk. Wyż. Szk. Roln. – Ped. w Siedlcach, Rolnictwo. 20: 11--21. (in Polish with English summary)

KORNAŚ J., DUBIEL E. 1991. Land use and vegetation changes in hay-meadow in the Ojców National Park during last thirty years. Veröf. Geobot. Inst. ETH, Zürich, Stiftung Rübel 106: 209-231.

Mapa katastralna (Catastral map) sporządzona na podstawie operatów ewidencji gruntów z 27. 11. 1992. Przemyśl.

MATUSZKIEWICZ W. 1984. Przewodnik do oznaczania zbiorowisk roślinnych Polski. Wyd. 2. p. 298. Wydawnictwo Naukowe PWN, Warszawa. (in Polish)

MATUSZKIEWICZ W. 2001. Przewodnik do oznaczania zbiorowisk roślinnych Polski. p. 537. Wydawnictwo Naukowe PWN, Warszawa. (in Polish)

MEDWECKA-KORNAŚ A., KORNAŚ J., PAWŁOWSKI B., ZARZYCKI K. 1972. Przegląd ważniejszych zespołów roślinnych Polski. In: W. Szafer, K. Zarzycki (eds). Szata roślinna Polski, Vol. 1. pp. 279-481. Państwowe Wydawnictwo Naukowe, Warszawa. (in Polish)

MICHALIK S. 1990. Przemiany roślinności łąkowej w toku sukcesji wtórnej na stałej powierzchni badawczej w Ojcowskim Parku Narodowym [Changes in meadow vegetation due to secondary succession on a permanent study plot in Ojców National Park]. Prądnik, Prace Muz. Szafera 2: 149-159. (in Polish with English summary)

MIREK Z., PIĘKOŚ-MIRKOWA H., ZAJĄC A., ZAJĄC M. 2002. Flowering plants and Pteridophytes of Poland – a checklist. Biodiversity of Poland. W. Szafer Institute of Botany, Polish Acad. Scien. 1: 1-442. Kraków.

NIEDŹWIEDŹ T., OBRĘBSKA-STARKEL B. 1991. Klimat. In: I. Dynowska., M. Maciejewski (ed.), Dorzecze górnej Wisły. 1. p. 341. Warszawa–Kraków. (in Polish)

NOY-MEIR I., GUTMAN M., KAPLAN Y. 1989. Responses of mediterranean grassland plants to grazing and protection. J. Ecol. 77: 290-310.

OOMES M.J.M., MOOI H. 1981. The effect of cutting and fertilizing on the floristic composition and production of an *Arrhenatheretum elatioris* grassland. Vegetatio 47: 233-239.

OZIMEK E. 1993-1994. Obszary i obiekty przyrodnicze województwa przemyskiego objęte ochroną prawną. Roczn. Przem. 29-30 [6 (1)]: 87-105. (in Polish with English summary)

PEET R.K. 1978. Forest vegetation of Colorado front range; patterns of species diversity. Vegetatio 37: 65-78.

PRUSINKIEWICZ Z., BEDNAREK R. 1999. Gleby. In: L. Starkel (ed.), Geografia Polski – Środowisko Przyrodnicze, p. 373-396. Państwowe Wydawnictwo Naukowe, Warszawa. (in Polish)

TER BRAAK C.J. 1987. Canoco – a Fortran program for canonical community ordination by (partial) (detrended) (canonical) correspondence analysis, principal component analysis and redundancy analysis (Version 2.2). Technical Report LWA-88-02. Agricult. Math. Group, Wageningen.

TER BRAAK C.J. 1990. Update notes: CANOCO version 3.10. Agricult. Math. Group, Wageningen.

THOMPSON K., BAKKER J.P., BEKKER R.M. 1997. Soil seed banks of NW Europe: methodology, density and longevity. Cambridge University Press, Cambridge.

WILDI O., ORLÓCI L. 1996. Numerical exploration of community patterns. A guide to use of MULVA-5. 2 ed., p. 171. SPB Academic Publishing.

WILSON D. 1994. The contribution of grazing to plant diversity in alpine grassland and helt. Austral. J. Ecol. 19 (2): 137-140.

WŁAD P. 1996. Regiony fizycznogeograficzne okolic Przemyśla. Roczn. Przem. 32 (2): 3-41. (in Polish with English summary)

WÓJCIK Z. 1998. Zbiorowiska segetalne Pogórza Przemyskiego i jego najbliższego otoczenia [Segetal communities of the Przemyśl Foothills and their neighborhood]. Fragm. Flor. Geobot. Ser. Polonica 5: 117-164. (in Polish with English summary)

ZEMANEK B. 1991 The phytogeographical division of the Polish East Carpathians. Zesz. Nauk. Uniw. Jagiell. Prace Bot. 22: 81-119.