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Wojciech RÓŻAŃSKI*, Elżbieta PĄNCER-KOTEJOWA*,
Krystyna GRODZIŃSKA**

*Department of Forest Botany and Nature Conservation, Agricultural University,
Al. 29 Listopada 46, 31–425 Cracow, Poland
**Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31–512 Cracow, Poland

VEGETATION OF THE RATANICA WATERSHED (CARPATHIAN FOOTHILLS, SOUTHERN POLAND)***

ABSTRACT: In this study, diversity and distribution (a map about 1:10000) of plant communities of the Ratanica watershed (2.415 km^2), a right-bank tributary of the Raba river, are presented. The results were compared with a map of soil distribution. It enabled analysis of the variability of soil units in the plant communities. On the basis of ecological indicator values, mean trophism coefficients were calculated for selected syntaxa.

KEY WORDS: map of vegetation, soil–community relationship, indicator values, Carpathian Foothills.

1. INTRODUCTION

Ecological studies in the forest watersheds have been carried out for a long time (Likens et al. 1977, Grodziński et al. 1984, Swank and Crossley 1987). Their main target is estimation of the chemical elements cycling in the ecosystems. Botanical studies are seldom performed simultaneously. Vegetaion variety, its anthropogenic deformation and different ways of management influence the biogeochemical cycles (Hornung et al. 1990). For this reason detail phytosociological

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analysis was included to biogeochemical studies in a small watershed of the Ratanica stream (Laskowski et al. 1993a, 1993b, Szarek et al. 1993) (Fig. 1).

The Ratanica watershed (Southern Poland) is under the pressure of not very high but long lasting pollution influx. The Ratanica stream drains into drinking water reservoir on the Raba river near Dobczyce (Fig. 1). Therefore, results of the study are not only of cognitive value, but also give us information of considerable importance to water management in the region.

Main research – on elements cycle – was carried out at a few selected plots. Physiographic research, including this study, concerned spatial variability of the watershed. It enabled evaluation to what extent the study object selected is typical of the whole region. The aim of this study was to characterise vegetation and to describe spatial relationships between plant communities and their association with various types of habitat.

2. METHODS

Plant communities were identified on the basis of Braun-Blanquet (1964) method. Names of plant species according to "Flora Europaea" (Tutin et al. 1964–1980) and Ochyra and Szmajda (1978) were adopted.

Boundaries of plant communities were marked out on a geodetic network at a scale of 1:5000. Species composition and tree-stand volume were assessed on the basis of relascope measurements (constant = 4). For charting of the forested part of the study area and a survey of the tree-stand, a grid of 116 random sample plots (in 100 x 100 m layout) established for the study of the herb layer structure was used (Pancer-Kotejowa and Różański 1992).

The relationship between vegetation and habitat conditions was determined with the use of ecological indicator values (Ellenberg 1974, Zarzycki 1984) and by comparing a typologic map of the watershed's soils (Adamczyk et al. 1989) with the vegetation map.

For all distinguished plant communities, trophism coefficient was calculated as an arithmetic mean of trophism values of individual species forming a given community. The following values characterising trophism of the habitat typical of a given species were adopted from Zarzycki (1984): (1) extremely oligotrophic soils, (2) oligotrophic soils, (3) mesotrophic soils, (4) eutrophic soils, (5) extremely eutrophic soils (often overfertilized). The modal value for these values distribution was also calculated. Tree species were taken into consideration only within the herb layer, where their occurrence is spontaneous. Seedlings were ignored as the most ephemeral element of phytocoenoses.

Cartographic comparison between vegetation and soils included bringing both maps to the same scale and projecting on them the identical network of points, for which plant community and soil unit readings were taken. After points that appeared

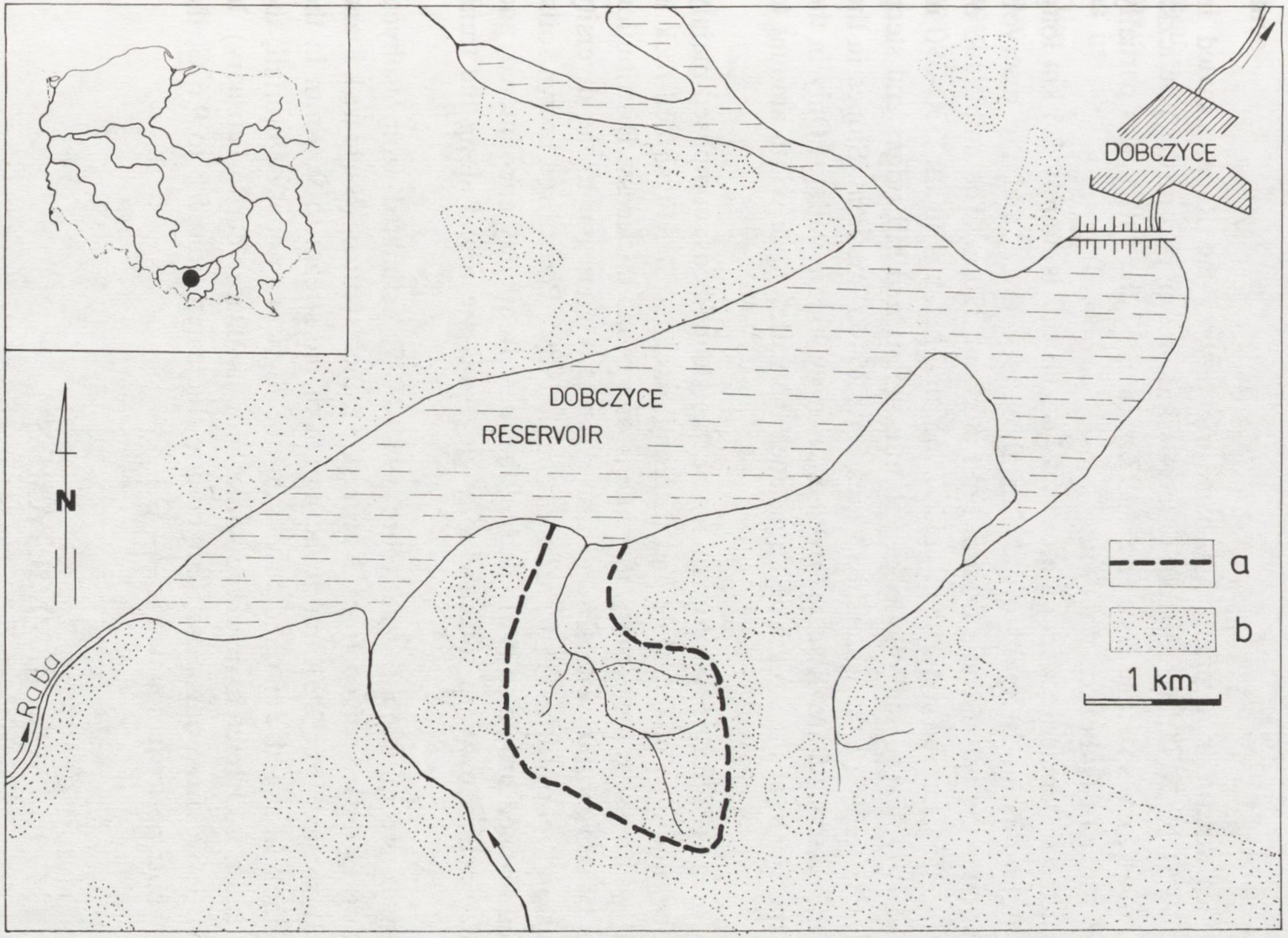

Fig. 1. Situation of the Ratanica watershed
a – a borderline of the watershed; b – forests

on the units' borderlines had been rejected, 403 records of vegetation and soil were left for further analysis.

3. DESCRIPTION OF THE STUDY AREA

The Ratanica stream is a small right-bank tributary of the Raba, situated in southwestern (49°51'N; 20°02'E), adjacent to the Beskid Średni, part of the Wieliczka Foothills (Klimaszewski and Starkel 1972). In 1987 the valley was partially flooded by the water of Dobczyce reservoir.

At present, the watershed covers an area of 241.5 ha and is merely 2.6 km long (Fig. 1). Its highest point is a hill of 424 m above sea level, and the reservoir shoreline constitutes the watershed's bottom limit at about 270 m. The amplitude of relief amounts to 154 m, and more than half of the area belongs to the 330–390 m zone. The relief is typical of the Wieliczka Foothills – flattened hill ridges and steep slopes prevail. Over 30% of the watershed's area is of 25–40° gradient. Slopes in the upper part of the watershed are dissected by deep, narrow stream valleys. Only in the lower part of the trunk, at the stretch of 1 km, does the valley floor width amount to 50–100 m.

The study area is built of Flysh formations of the Istebna beds, composed mainly of the sandstone, and also of the shale and the conglomerate. The Flysh bed-rock is partly covered with lessive Quaternary formations of various thickness. Distribution and properties of soils in the watershed exhibit a direct relationship to the diversity of the bed-rock and relief forms (Adamczyk et al. 1989). Podzolised brown soils, acid brown and leached brown soils are among the most frequently encountered, and podzols are also common. Warp soils and silty-gley soils are found along the trunk valley.

Mean annual precipitation of the years 1954–1987, estimated from isohyets drawn according to data received from 3 nearest weather stations (Suliński and Kucza 1993), ranged from 820 mm at the mouth of the stream to 900 mm in the upper part of the watershed. June and July bring the highest amount of rainfall, the lowest precipitation is characteristic of the winter months (December to February). In the years 1954–1987, mean annual air temperature fluctuated from 5.8 to 9.6°C; the mean for the whole period amounted to 7.4°C.

4. VEGETATION

4.1. GENERAL CHARACTERIZATION

The Valley of Ratanica is one of the most wooded in Carpathian Foothills: after its lower part has been flooded, the forest cover exceeds 50%. Forests overgrow the area of 121.76 ha, 90% of which is constituted by a compact forest complex, situated

in the upper part of the watershed. Apart from this complex, only small copses are encountered on steep, not cultivable slopes. The remaining part of the area is dominated by fields and intensively cultivated meadows. A share of semi-natural meadow communities is small. They are restricted to steep slopes and very humid habitats, especially at the valley floor. In few cases semi-natural, mowed meadows developed on abandoned fields.

Vegetation of the Ratanica valley has undergone major changes and even relatively least changed forests are of anthropogenic character. It manifests itself mainly in the domination of coniferous species (the pine and the larch – 75%) as well as in occasional introduction of foreign species: *Pinus nigra, Pseudotsuga taxifolia, Quercus rubra* (Table 1). Apart from now commonly encountered pines, beeches and larches, important forest–forming role might have been played by the fir, the hornbeam, the oak and the lime-tree, now occurring only marginally. However, it is not known what the actual share of these species was.

Table 1. Species composition of tree-stand in the valley of Ratanica
A – according to the dbh–section area in 20 round sample stands (Szwagrzyk 1992), B – according to 118 relascope measurements, C – according to the volume in 30 round sample stands (Raimer et al. 1990)

Species	Species share (%)		
	A	B	C
Pinus sylvestris	49	52	63
Fagus sylvatica	38	25	21
Larix decidua	9	10	11
Alnus glutinosa	1.5	3	–
Picea abies	0.7	3	–
Quercus robur et *Q. petraea*	0.4	3.5	–
Others*	1.4	3.5	5

**Betula pendula, Betula obscura, Prunus avium, Quercus rubra, Carpinus betulus, Sorbus aucuparia, Fraxinus excelsior, Abies alba, Acer pseudoplatanus, Alnus incana, Pinus nigra.*

During the last 20–30 years, the process of changes in methods of arable land cultivation could be observed in Poland. Intensification of fertilization, use of chemicals and machines, introduction of new crops and monotypization of cultivated meadows have caused destabilisation of the meadow and arable field communities. As a result, species composition of many plant communities is so heterogenous that their unambiguous classification is impossible.

On the other hand, anthropogenic pressure on forests and low quality soils has decreased. Raking up of the forest bedding and dry twigs collecting have practically been given up, and pasturage has recently been on the decline too. The beech expansion and decline of acidophilous species, observed not only in the valley of Ratanica, might be to a large extent stimulated by these processes.

4.2. TREE-STAND

At the moment, 40–80 years old beech and pine tree-stands are dominating in the valley of Ratanica, locally also with an addition of the larch (Fig. 2). These kinds of tree-stand are very common, especially in the Flysh part of the Wieliczka Foothills (Różański et al. 1987). However, a very small share of the fir, which in the Carpathian Foothills usually plays a significant role, ought to be considered as one of the important features intrinsic to forests of the Ratanica (Table 1). A very small share (restricted to a few plots – Fig. 2) of monotypical tree-stands is a very advantageous feature of the forest complex considered, since it creates very good opportunity for natural reconstruction of these forests. The studies of the structure (Szwagrzyk 1992) and dbh increment (Rieger et al. 1992) have shown considerable dynamics of the beech, which is the only species occurring in all volume classes (Fig. 3) and is characterized by the greatest dbh increment. The larch and the pine show signs of regression: they have their volume, respectively, 2 and 4 times smaller than the beech (Rieger et al. 1992). If this tendency keeps on, one may expect that within the next 20–30 years the beech will become a dominating species of the highest volume in the valley of Ratanica. The utilization of the forests, i.e. cutting the pine tree-stand, may even accelerate this process.

In detailed dendrometric measurements taken from 30 random sample-plots (situated every 200 m at the nods of the same grid), the large timber volume and total stand volume (large timber + undergrowth + wastewood) were found to average 254 $m^3\ ha^{-1}$ and 302 $m^3\ ha^{-1}$, respectively (Raimer et al. 1990). Within the Foothills, these values are relatively high – similar to those found in Carpathian lower montane forest. The volume increment is even greater. It amounts to 7.9 $m^3\ ha^{-1}\ yr^{-1}$ and 9.7 $m^3\ ha^{-1}\ yr^{-1}$ for large timber and total tree-stand, respectively. It is much higher than the average for Poland and for the Carpathians and indicates a large potential productivity of forest habitats in the valley of Ratanica, though high current volume increment results also from the young age of the tree-stand considered.

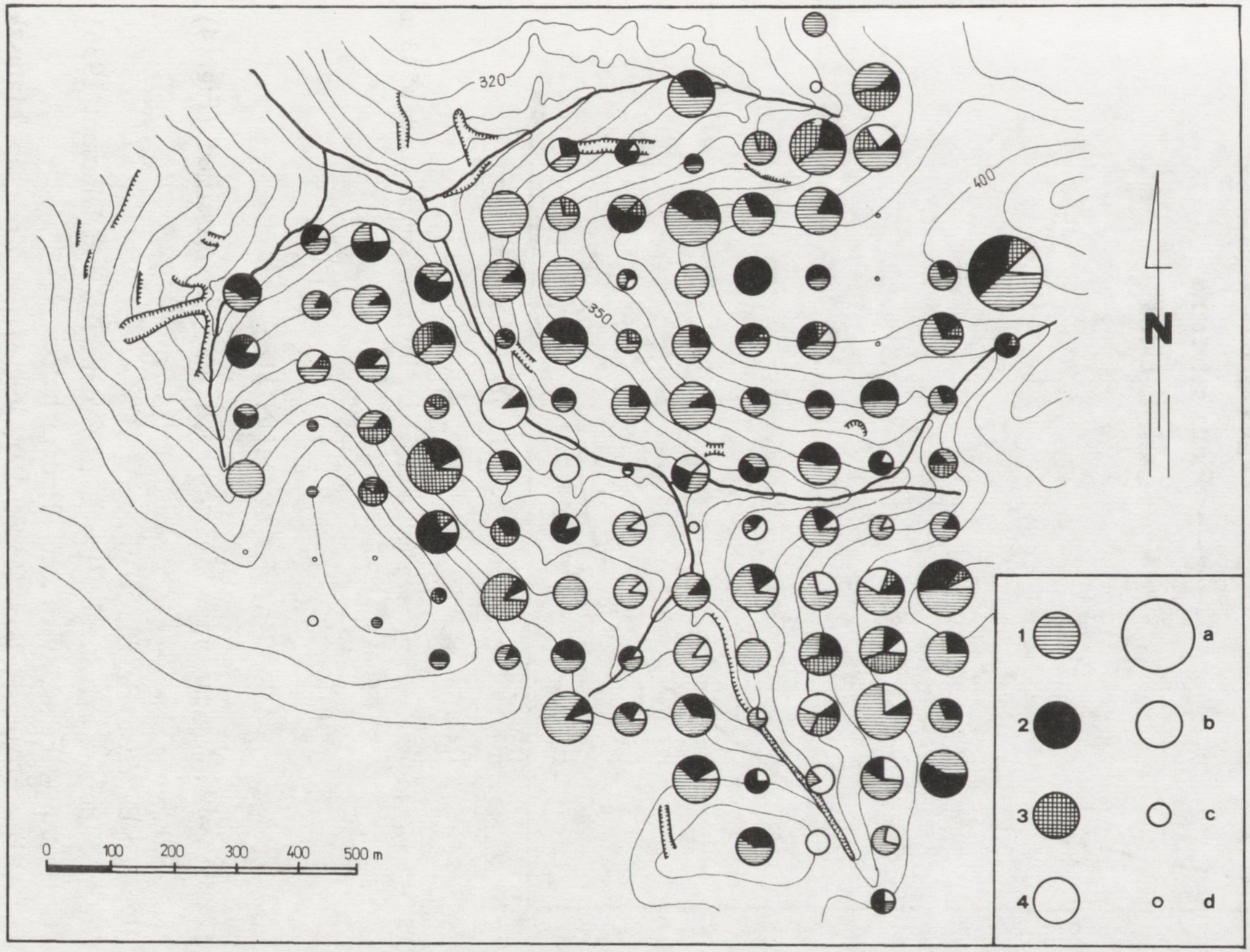

Fig. 2. Species composition of tree-stands in the Ratanica watershed (on the basis of 118 relascope sample areas)
1 – *Pinus sylvestris*, 2 – *Fagus sylvatica*, 3 – *Larix decidua*, 4 – other species (see Tab. 1); a sum of the dbh-section areas: a – 62 m^2 ha^{-1}, b – 40 m^2 ha^{-1}, c – 20 m^2 ha^{-1}, d – 4 m^2 ha^{-1}

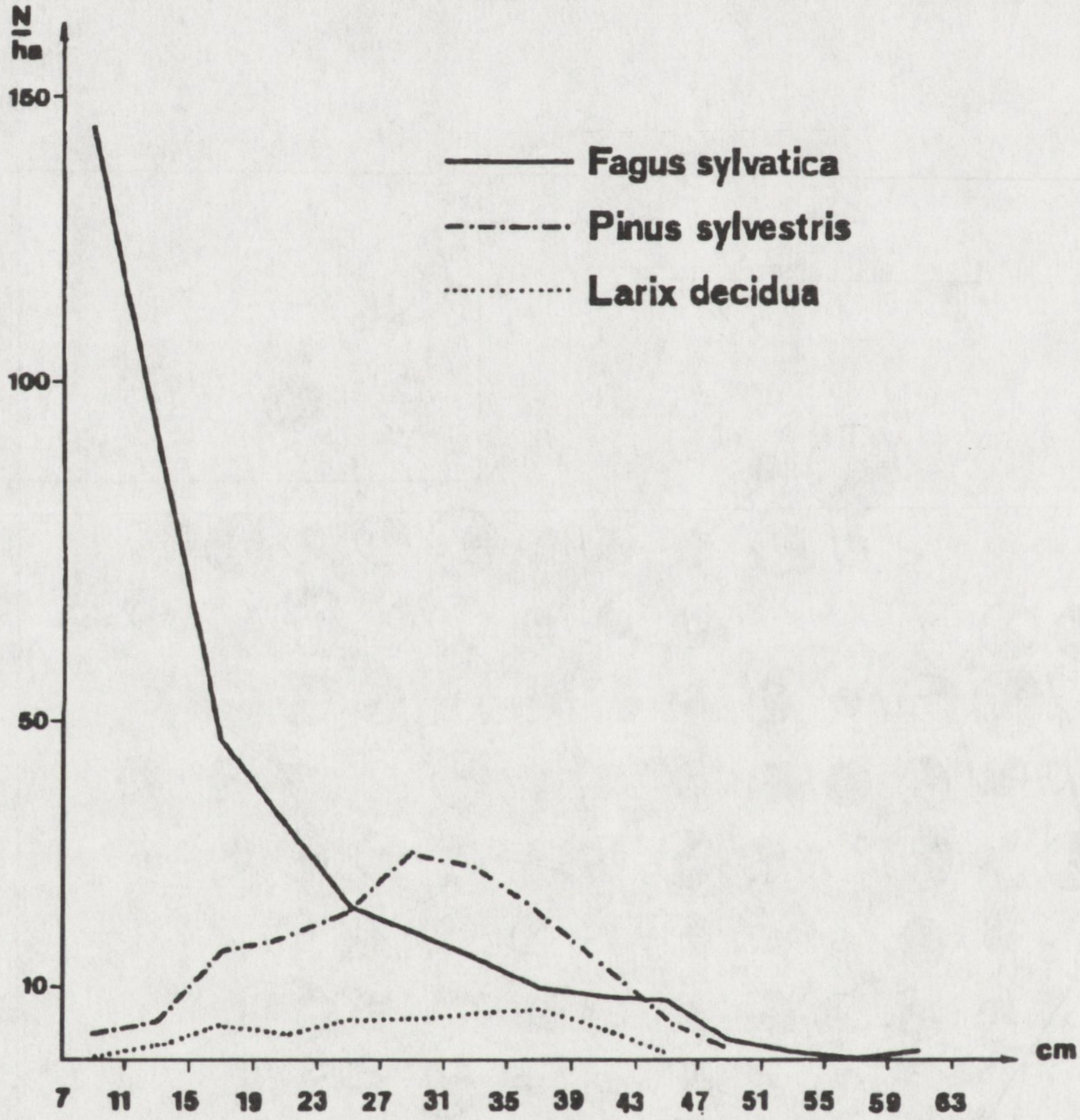

Fig. 3. Dbh structure in the Ratanica watershed (according to 20 round sample stands of 13 m radius, Szwagrzyk et al. 1992)

4.3. PLANT COMMUNITIES

The 12 phytosociological units differentiated may be classified (Fig. 4) as follows:

Class: Querco-Fagetea (Br.-Bl. et Vlieger 1937)

Order: Fagetalia sylvaticae [(Pawł. 1928 n.n.) R.Tx et Diemont 1936]

1. Community: Fagus sylvatica – Hedera helix

Alliance: Alno-Padion (Knapp 1942 em. Medw.-Korn. ap. Matuszk. et Borowik 1957)

2. Association: Carici remotae-Fraxinetum (Koch 1926) – fragments

Alliance: Carpinion betuli (Oberd. 1953)

3. Association: Tilio-Carpinetum (Tracz. 1962) – fragments

Alliance: Luzulo-Fagion (Lohm. et R.Tx. 1954)

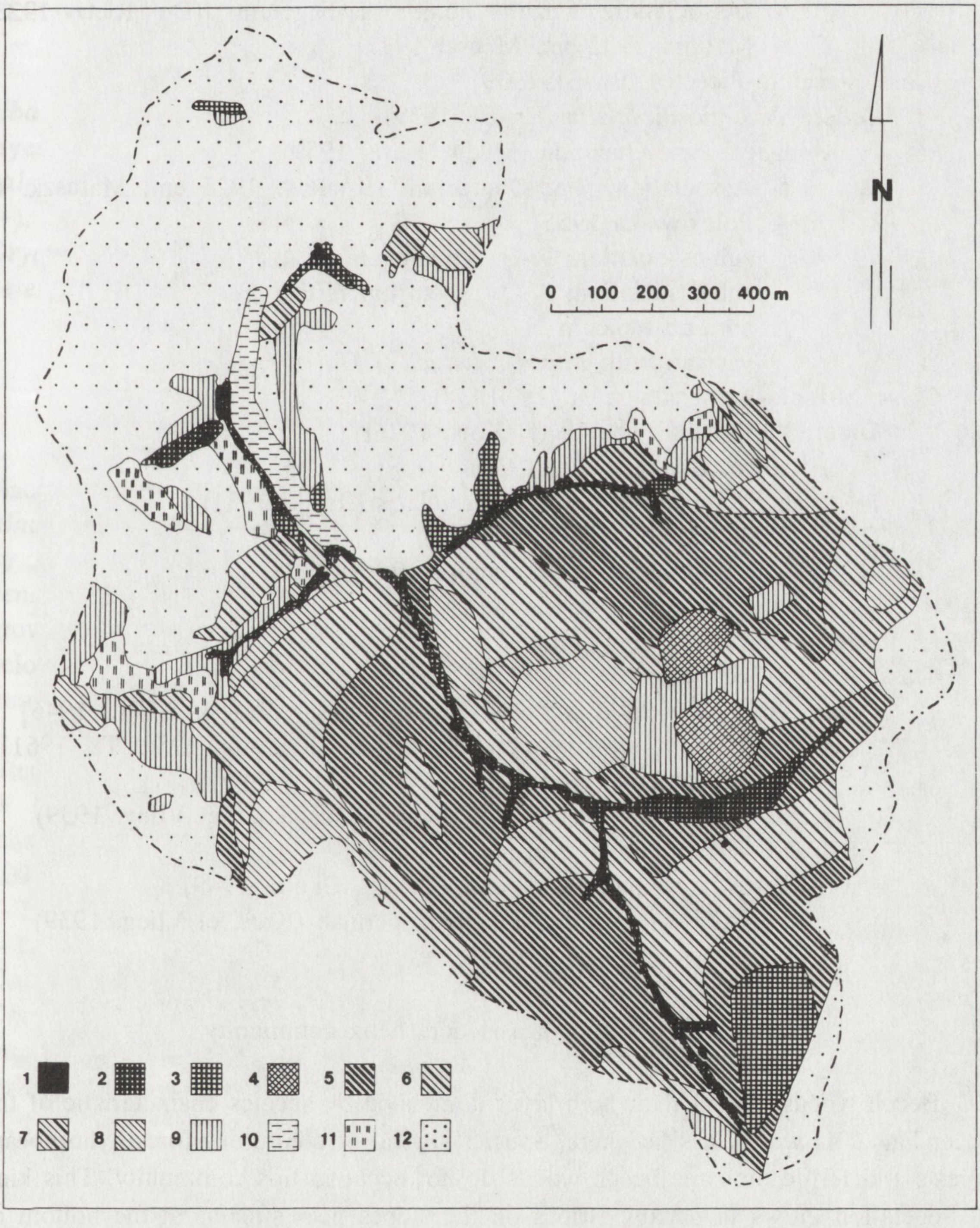

Fig. 4. Vegetation of the Ratanica watershed

1 – Alno-Padion, 2 – Fagus sylvatica-Hedera helix comm., 3 – Tilio-Carpinetum fragm.), 4 – Luzulo nemorosae-Fagetum, 5 – Pino-Quercetum rubetosum var. Fagus sylvatica, 6 – Pino-Quercetum rubetosum var. typicum, 7 – transitional stands between P.-Q. rubetosum var. typicum and P.-Q. typicum, 8 – Pino-Quercetum typicum, 9 – Pino-Quercetum s.l., 10 – Molinietalia, 11 – Arrhenatheretalia, 12 – Secali-Violetalia (Vicietum tetraspermae et Echinochloo-Setarietum)

4. Association: Luzulo nemorosae-Fagetum [(Du Rietz 1923) Markgr. 1932 em. Meusel 1937]
Class: Vaccinio-Piceetea (Br.-Bl. 1939)
Order: Vaccinio-Piceetalia (Br.-Bl. 1939)
Alliance: Pino-Quercion (Medw.-Korn. 1959)
5. Association: Pino-Quercetum (Kozłow. 1925 em. Matuszk. et Polakowska 1955)
sub-association: P.-Q. typicum
sub-association: P.-Q. rubetosum hirti
variant: typicum
variant: with *Fagus sylvatica*
Class: Molinio-Arrhenatheretea (Tx. 1937)
Order: Molinietalia coeruleae (Koch 1926)
Alliance: Calthion (Tx. 1936)
6. Association: Cirsietum rivularis (Ralski 1931)
Order: Arrhenatheretalia (Pawł. 1928)
Alliance: Arrhenatherion elatioris (Pawł. 1928)
7. semi-natural meadow communities
8. grass cultivation community
Class: Rudero-Secalietea (Br.-Bl. 1936)
Order: Secali-Violetalia arvensis [Siss. (1943 ap. Br.-Bl. et Tx.) 1946]
Sub-Order: Polygono-Chenopodietalia [(Tx. et Lohm. 1950) Tx. 1961]
Alliance: Panico-Setarion (Siss. 1946)
9. Association: Echinochloo-Setarietum (Krus. et Vlieg. 1939)
Sub-Order: Centauretalia cyani (Tx. 1937)
Alliance: Aperion spicae-venti (Tx. ap. Oberd. 1949)
10. Association: Vicietum tetraspermae (Krus. et Vlieg. 1939)

4.3.1. Fagus sylvatica-Hedera helix community

Beech woods having their herb layer dominated by species characteristic of the order Fagetalia were classified here. Species typical of coniferous forests, hornbeam forests and fertile montane beech woods do not occur in this community. This kind of vegetation grows in narrow stripes on the slopes near streams at the bottom of deep ravines. In the Carpathian Foothills, similar habitats are occupied by the beech wood, Dentario glandulosae-Fagetum, but in the valley of Ratanica species characteristic of this community (*Cardamine glanduligera, Veronica montana*) are associated with more humid habitats: alder-ash woods. Below an exemplary relevé from the beech wood *Fagus sylvatica-Hedera helix* is given:

Relevé no 120. 12 July 1990. Sect. 127. A slope by a stream; tree-stand at the reverse slope thinned, therefore the site laterally exposed to sunlight. Altitude 360 m, exposure SW, inclination 12°. Tree-stand: maximum dbh 75 cm, average

35 cm, maximum hight 30 m, average 26 m. Area 100 (256) m^2. Coverage: a – 85%, b – 5%, c – 95%, d +.

Trees: *Fagus sylvatica* a–5, *Pinus sylvestris* a–1, *Picea abies* b–+, c–+, *Abies alba* (planted) b–10. Shrubs: *Sambucus nigra* b– +, *Daphne mezereum* b–+. Herb layer: Ch. Fagetalia et Querco–Fagetea: *Rubus hirtus* 5, *Hedera helix* 3, *Lamiastrum galeobdolon* 1, *Anemone nemorosa* +, *Polygonatum multiflorum* +, *Stachys sylvatica* (+), *Atrichum undulatum* +. Other: *Athyrium filix-femina* 2, *Oxalis acetosella* 2, *Dryopteris dilatata* +, *D. carthusiana* +, *Luzula luzuloides* +, *L. pilosa* +, *Dicranella heteromalla* +.

4.3.2. Carici remotae-Fraxinetum (fragments)

Only small stands of alder-ash woods have survived. They are associated with places of water seepage at slope breaks within stream valleys. Tree-stand consists of *Alnus incana, A. glutinosa* and *Fraxinus excelsior*. The herb layer is often dominated by *Equisetum telmateia*, but a species characteristic of this community, *Carex pendula*, was found only in a few sites by the stream in such narrow ravines that the growth of alder-ash woods was impossible. One of the exceptions is the relevé given below. As a rule, stands dominated by *Equisetum telmateia* occur in places relatively more exposed to sunlight, such as clearings or forest edges.

Relevé no 81. 3 Sept 1987 (supplemented 3 May 1988). A stream ravine, laterally hollowed with water seepage. Gley- silt soil. Altitude 355 m., exposure W (NNW), inclination 12°. Tree-stand: maximum dbh 25 cm, average 18 cm, maximum hight 24 m (*Picea abies*) and 20 m (*Alnus glutinosa*), average 18 m. Area 100 (256) m^2. Coverage: a – 80%, b – 15%, c – 100%, d – 5%. Trees: *Alnus incana* a–2, b–2, c–(+); *Alnus glutinosa* (a–1), *Fraxinus excelsior* a–3, b–1, c–+; *Picea abies* a–1. Shrubs: *Sambucus racemosa* b–+. Herb layer: Ch. and Diff. Alno–Padion: *Caltha palustris* +, *Cardamine amara* +(1), *Carex pendula* +, *Carex remota* 1, *Chrysosplenium alternifolium* +, *Equisetum telmateia* +, *Festuca gigantea* +, *Impatiens noli-tangere* +, *Lycopus europaeus* +, *Stachys sylvatica* +, *Plagiomnium undulatum* 2. Ch. Fagetalia et Querco-Fagetea: *Anemone nemorosa* +, *Carex brizoides* 1, *C. sylvatica* 1, *Cardamine glanduligera* 1, *Dryopteris filix mas* (+), *Lamiastrum galeobdolon* 2, *Lysimachia nemorum* +, *Rubus hirtus* 4, *Veronica montana* (+), *Viola sylvatica* +, *Atrichum undulatum* 1. Other: *Ajuga reptans* +, *Athyrium filix-femina* +, *Dryopteris carthusiana* +, *Myosotis scorpioides* +, *Oxalis acetosella* 1, *Ranunculus repens* +, *Rubus* sp. +, *Senecio nemorensis* ssp. *fuchsii* (+), *Urtica dioica* 2, *Brachythecium rivulare* 1, *B. rutabulum* 1, *Conocephalum conicum* +, *Dicranella heteromalla* +, *Eurhynchium hians* +, *Rhizomnium punctatum* +.

Vegetation constituting the herb layer of alder-ash woods usually occurs in stands: vegetation of springs – *Carex palustris, Cardamine amara, Caltha palustris, Myosotis scorpioides* – dominates along tiny, trickling watercourses, and species of the order Fagetalia, with the ubiquitous bramble (mainly *Rubus hirtus*) in largest quantity, occur in adjusting, but slightly higher located sites.

4.3.3. Tilio-Carpinetum (fragments)

The hornbeam occurrence in tree-stand and undergrowth is the only floristic criterion allowing differentiation of fragments of this community. Despite little variety in species composition resulting, perhaps, from planting the pine, stands identified as an oak-hornbeam forest grow in a well defined habitat: they occur on moderately moist, leached-brown, relatively deep soils that develop on Quaternary lessive sheets. Stands of the oak-hornbeam forest are encountered mainly in the upper part of the watershed (Fig. 4). Below an exemplary relevé is given:

Relevé no 95. 3 Sept. 1987 (supplemented 3 May 1988). Sect. 128. A part of a slope near the crest. Area 100 (256) m^2. Altitude 370 m, exposure W, inclination 2°. Tree-stand: maximum dbh 34/16 cm, mean 30/10 cm, maximum height 21/13 m, mean 19/10 m. Area 100 (256) m^2.

Coverage: a1 – 35%, a2 – 85%, b – 25%, c – 80%, d –. Trees: *Carpinus betulus* a2–1, b–+, *Quercus robur* a2–2, *Q. petrea* a2–2, *Q. robur* + *Q. petrea* c–+, *Fagus sylvatica* a2–3, b–1, *Pinus sylvestris* a1–3, *Sorbus aucuparia* a2–2, c–+, *Abies alba* b–1, c–1. Shrubs: *Viburnum opulus* b–(+), c–(+), *Frangula alnus* b–2, c–+. Herb layer: Ch. Fagetalia: *Anemone nemorosa* (+), *Carex brizoides* 2, *Hedera helix* 1, *Rubus hirtus* 4. Other: *Athyrium filix-femina* +, *Dryopteris dilatata* +, *D. carthusiana* +, *Maianthemum bifolium* +, *Oxalis acetosella* +, *Rubus* sp. (+).

4.3.4. Luzulo nemorosae-Fagetum

Acidophilous beech woods occur only on a sloping ridge and southern slopes in the eastern part of the watershed (Fig. 4), on lessive soils. A typical herb layer, with a large share of *Luzula luzuloides* develops within the old beech tree-stand, in which the pine is only a minor component.

Relevé no 87. 22 July 1987 (supplemented 20 April 1988). Sloping ridge. Altitude 370 m, exposure S (SSW), inclination12°. Tree-stand: maximum dbh 38 cm, mean 24 cm, maximum height 23 m, mean 18 m. Area 100 (256) m^2.
Coverage: a – 98%, b – +, c – 15%, d – +.
Trees: *Fagus sylvatica* a–5, *Pinus sylvestris* a–2, *Sorbus aucuparia* b–+, c–+, *Quercus robur* c–+, *Prunus avium* c–+. Shrubs: *Frangula alnus* c–+. Herb layer: Ch. Luzulo-Fagetum: *Luzula luzuloides* 2. Ch. Fagetalia: *Dryopteris filix-mas* (+), *Rubus hirtus* +. Ch. Vaccinio-Piceetalia: *Vaccinium myrtillus* 1. Other: *Athyrium filix-femina* 1, *Dryopteris carthusiana* +, *Luzula pilosa* +, *Maianthemum bifolium* 1, *Dicranella heteromalla* +.

4.3.5. Pino-Quercetum

Mixed forest is the dominating plant association (Table 2, Fig. 4). It covers over 90% of the overall forest area, grows in relatively diverse habitats and, despite little variety in species composition, shows considerable variability. Tree-stand consists of the pine and the beech, which is the best restoring species in the watershed area. On

the other hand, both oak species play only little role in the community; as mentioned earlier, both were introduced by man. Two sub-associations may be distinguished within Pino- Quercetum community: typical, which do not differ significantly from lowland mixed forests, and specific to Foothills bramble sub-community, P.-Q. rubetosum hirti (Różański et al. 1987), most commonly encountered in the watershed area.

Table 2. A comprehensive table for the Pino-Quercetum association
PQt – Pino-Quercetum typicum, PQrt – Pino-Quercetum rubetosum var. typicum, PQrF – Pino--Quercetum rubetosum var. Fagus sylvatica, F – frequency, I – index of coverage (Braun-Blanquet 1964), a, b, c – vegetation layers: a – above 6 m, b – 0.5–6 m, c – below 0.5 m, Ch. – local characteristic species, Diff. – local differentiation species

Community		PQt		PQrt		PQrF	
Number of relevés		10		10		10	
		F	I	F	I	F	I
1		2		3		4	
Trees:							
Pinus sylvestris	a	8	2102	8	2925	10	3550
	b	6	104	1	50	•	–
	c	9	232	3	3	•	–
Fagus sylvatica	a	6	1575	9	2402	10	3750
	b	6	880	8	656	7	850
	c	5	5	3	3	1	1
Quercus robur	a	1	1	1	375	2	2
	b	6	180	2	51	3	–
Q. robur + Q. petraea	c	9	9	7	7	7	7
Picea abies	a	1	1	•	–	3	52
	b	3	52	5	229	6	327
	c	3	3	2	2	5	5
Sorbus aucuparia	a	1	50	1	1	1	1
	b	6	202	5	54	2	2
	c	7	56	10	157	5	5
Abies alba	a	•	–	1	1	1	1
	b	8	256	7	903	5	825
	c	4	53	2	2	4	4
Betula pendula	a	1	175	4	227	1	1
	c	10	255	5	54	1	1

Table 2, continued

1		2		3		4	
Larix decidua	a	1	50	2	425	2	2
	b	2	51	•	–	•	–
	c	2	2	•	–	•	–
	a + b + c	4	103	2	425	2	2
Populus tremula	b	1	50	1	50	•	–
	c	5	5	2	2	•	–
Shrubs:							
Frangula alnus	b	8	1353	10	952	4	178
	c	4	1380	9	280	3	3
Salix caprea	b	2	2	1	1	•	–
	c	4	4	3	3	•	
Herbs and Bryophyta:							
Ch. and Diff. Pino-Quercion and Pino-Quercetum							
Pteridium aquilinum		8	1826	7	827	3	52
Molinia coerulea arundinacea		6	554		175	•	–
Carex pilulifera		6	6	4	3	2	2
Luzula pilosa		5	5	9	204	7	56
Diff. Pino-Quercetum rubetosum hirti:							
Rubus hirtus		7	279	10	3375	10	5050
Dryopteris carthusiana		1	1	10	59	9	58
Athyrium filix-femina		•	–	7	36	9	9
Carex brizoides		•	–	3	177	3	177
Ch. Vaccinio-Piceetea and Vaccinio-Piceetalia:							
Vaccinium mytrillus		10	2625	10	3000	10	380
Polytrichum attenuatum		9	553	8	106	3	3
Leucobryum glaucum		9	455	3	3	•	–
Calluna vulgaris		9	58	2	2	•	–
Pleurozium schreberi		7	453	2	2	•	–
Sieglingia decumbens		3	52	•	–	•	–
Thelypteris limbosperma		1	1	6	55	1	1
Trientalis europaea		1	1	4	53	•	–

1	2		3		4	
Dryopteris dilatata	1	1	2	2	3	2
Others:						
Luzula luzuloides	8	427	7	203	1	50
Epilobium angustifolium	5	54	1	1	•	–
Rubus sp.	5	5	4	4	1	1
Rubus plicatus	4	4	3	3	1	1
Agrostis capillaris	3	52	2	2	•	–
Dicranella heteromala	3	52	1	1	2	2
Rubus idaeus	2	2	3	3	•	–
Maianthemum bifolium	•	–	6	55	4	4
Oxalis acetosella	•	–	1	175	8	726

Sporadic species. Trees: *Acer pseudoplatanus* PQt-c, *Alnus glutinosa* (introd.) PQt-b, PQrt-b, *Carpinus betulus* PQt-b, PQrF-a, *Prunus avium* PQrF-c, *Pseudotsuga menziesii* (introd.) PQrt-b, *Pyrus communis* PQeF-c, *Quercus petraea* PQrt-a,b, PQrF-b. Shrubs: *Corylus avellana* PQrF-b, *Juniperus communis* PQt-b, *Salix* sp. PQrt-b, *Sambucus racemosa* PQrt-b. Herbs and Bryophyta: Ch. and Diff. Pino-Quercion: *Genista tinctoria* PQt, PQrt, *Convallaria majalis* PQrt. Ch. Vaccinio-Piceetalia: *Blechnum spicant* PQrt, *Deschampsia flexuosa* PQt, *Dicranum undulatum* PQt, *Gentiana asclepiadea* PQrt, PQrF, *Lyvopodium annotinum* PQrt, *Huperzia selago* PQrt, *Solidago virgaurea* PQrt, *Sphagnum girgensohni* PQrt. Ch. Fagetalia and Querco-Fagetea: *Anemone nemorosa* PQrt, PQrF, *Catharinea undulata* PQrt, *Dryopteris filix-mas* PQrF, *Equisetum sylvaticum* PQrt, PQrF, *Lamiastrum galeobdolon* PQrF, *Poa nemorallis* PQrt. Others: *Anthoxanthum odoratum* PQt, PQrt, *Calamagrostis epigejos* PQt, PQrt, *Carex pallescens* PQt, PQrt, *Carex* sp. PQt, PQrt, *Deschampsia caespitosa* PQrt, *Galeopsis bifida* PQrt, *Galeopsis tetrahit* PQrt, *Hieracium murorum* PQrt, PQrF, *Holcus lanatus* PQt, *Luzula multiflora* PQt, PQrt, *Medicago sativa* PQrt, *Gymnocarpium dryopteris* PQrt, *Thelypteris phegopteris* PQrF, *Potentilla erecta* PQt, PQrt, *Senecio fuchsii* PQt, PQrF, *Stellaria media* PQt, *Plagiothecium* sp. PQrt.

In Pino-Quercetum typicum, features typical of coniferous forest prevail. In tree-stand, the pine dominates over the beech, and the herb layer is characterized by the domination of the blueberry *Vaccinium myrtillus* and frequent occurrence of *Molinia coerulea* ssp. *arundinacea, Calluna vulgaris, Leucobryum glaucum* and *Pleurozium schreberi.* Species of the order Fagetalia are rare; only *Rubus hirtus* occurs frequently. A typical mixed forest is associated with podzolic, sandy soils and is restricted to flattened crests (Fig. 4), at which intensive soil leaching takes place.

Pino-Quercetum rubetosum hirti covers around 80% of the overall forest area. Two variants resulting from differences in edaphic conditions and covering comparable areas, can be distinguished within the area studied.

The typical variant is a mixed forest of the richest species composition in the area studied (Table 2). *Thelypteris limbosperma* and *Trientalis europaea*, as well as such rare species as *Blechnum spicant, Lycopodium annotinum* and *Huperzia selago*

are found here most frequently. Also a group of deciduous forest species is more numerous here, though none of the species, except for *Rubus hirtus*, have high constancy or degree of abundance. The coniferous forest variant with the bramble develops on loamy-sand and sandy podzolic soils.

The variant with the beech (P.-Q. rubetosum hirti variant *Fagus sylvatica*) is associated with more fertile soils: fine-sands and loamy fine-sands. Its origin has not been entirely clarified. However, studies carried out in the valley of Ratanica confirm Różański's et al. (1987) suggestion that the community, or at least some part of it, could have developed in habitats of high oak-hornbeam forests deteriorated during many years of their utilisation.

Stands that are now classified as this syntaxon are characterized by a large share of the beech in tree-stand, and, therefore, the forest floor is often strongly overshadowed and the herb layer does not develop very well. Species adapted to overshadowed sites (*Oxalis acetosella, Athyrium filix-femina, Dryopteris carthusiana*) are found here with considerable frequency. Substantial reduction in the number and abundance of coniferous forest species and a slightly larger share of species of the order Fagetalia are the features that distinguish this variant from other mixed forests.

4.3.6. Cirsietum rivularis (fragments)

Stands of this community survived only in the central part of the watershed, on the flat, wet valley floor near water seepages. Heavy, loamy warp soils are difficult to dry and, in spite of existence of numerous drainage ditches, hygrophilous vegetation have favourable conditions here. Apart from the valley floor, only small fragments of semi-natural communities of the order Molinietalia occur.

The relevé given below represents the best preserved stand of *Cirsietum rivularis*:

Relevé no 5/88. 7 June 1988. Valley floor, altitude 285 m, silty-gley soil; a meadow adjacent to the alder groove. Mean herb layer height 50 cm, maximum 80 cm. Coverage 150%. Area 60 m^2.

Ch. Cirsietum rivularis and Calthion: *Cirsium rivulare* 3, *Caltha palustris* +, *Lotus uliginosus* 2, *Myosotis scorpioides* +. Ch. Molinietalia: *Cardamine pratensis* 2, *Carex panicea* +, *Crepis paludosa* 2, *Equisetum palustre* +, *Galium palustre* 1, *Juncus articulatus* +, *Lychnis flos-cuculi* 2, *Lysimachia nummularia* 1, *Lysimachia vulgaris* +, *Dactylorhiza majalis* +, *Scirpus sylvaticus* +, *Stachys palustris* +. Ch. Molinio-Arrhenatheretea: *Alopecurus pratensis* +, *Anthoxanthum odoratum* 3, *Cerastium fontanum* ssp. *triviale* 1, *Holcus lanatus* 3, *Lathyrus pratensis* +, *Plantago lanceolata* 1, *Poa trivialis* 1, *Ranunculus acris* +, *Rumex acetosa* 1, *Trifolium pratense* +, *Veronica chamaedrys* +. Other: *Ajuga reptans* +, *Alchemilla* sp. +, *Rhinanthus angustifolius* ssp. *grandiflorus* +, *Carex brizoides* +°, *Carex* sp. +, *Luzula campestris* +, *Peucedanum palustre* +, *Ranunculus repens* 2, *Climacium dendroides* 2, *Plagiomnium rostratum* +, *Rhitidiadelphus squarrosus*.

4.3.7. Semi-natural meadows of the alliance Arrhenatherion

Semi-natural (without sowing) meadows on moderately moist, mineral soils are rarely found within the watershed. They have evolved on fields that were left uncultivated. Depending on the soil productivity and the way of cultivation (intensity of fertilisation) their species composition is either similar to that of Arrhenatheretum elatioris, or shows a larger share of poor habitats species of the order Nardetalia. Meadows which are often grazed show an increase in abundance of pasture species, such as *Trifolium repens* or *Cynosurus cristatus*, however typical pastures are missing in the watershed area.

Two relevés are given below: the first represents a stand resembling Arrhenatheretum elatioris, the second is an example of the meadow community most frequently found in this area, with the domination of *Agrostis capillaris* and *Festuca rubra.*

Relevé no 20/88. 28 June 1988. Northern part of the watershed, adjacent to a road. Altitude 290 m, exposure: local – S, general – E, inclination 2° (a terraced slope). Mean herb layer height 60 cm, maximum 100 cm. Coverage 100%. Area 100 m^2.

Ch. Arrhenatheretum elatioris: *Arrhenatherum elatius* +, *Bromus hordaeceus* +, *Daucus carota*. Ch. Arrhenatherion and Arrhenatheretalia: *Achillea millefolium* +, *Agrostis capillaris* +, *Heracleum sphondylium* +, *Phleum pratense* 1, *Pimpinella major* +, *Stellaria graminea* +, *Taraxacum officinale* 1, *Trifolium dubium* +, *Trifolium repens* 2. Ch. Molinio–Arrhenatheretea: *Anthoxanthum odoratum* 2, *Cerastium fontanum* ssp. *triviale* +, *Dactylis glomerata* 1, *Festuca rubra* +, *Holcus lanatus* 4, *Leontodon autumnalis* +, *Leontodon hispidus* +, *L. hispidus* ssp. *danubialis* 1, *Plantago lanceolata* 1, *Poa pratensis* +, *Poa trivialis* 1, *Ranunculus acris* 1, *Rumex acetosa* 1, *Trifolium pratense* +, *Veronica chamaedrys* +. Other: *Elymus repens* +, *Anthemis arvensis* +o, *Holcus mollis* +, *Myosotis arvensis* +, *Rorippa* sp. +, *Ranunculus repens* 2, *Rumex acetosella* +, *Rumex obtusifolius* +.

Relevé no 8/88. 9 June 1988. Eastern slopes, among summer houses. Altitude 340 m, exposure NE, inclination 15–20°. Mean herb layer height 20 cm, maximum 80 cm. Coverage 98%. Area 100 m^2.

Ch. Arrhenatherion and Arrhenatheretalia: *Achillea millefolium* +, *Agrostis capillaris* 2, *Bellis perennis* +, *Pimpinella major* +, *Stellaria graminea* 1, *Taraxacum officinale* +, *Trifolium repens* 3. Ch. Molinio-Arrhenathereta: *Anthoxantum odoratum* 2, *Cerastium fontanum* ssp. *triviale* 1, *Dactylis glomerata* +, *Festuca rubra* 4, *Holcus lanatus* +, *Hypochoeris radicata* +, *Leontodon hispidus* var. *hastilis* +, *Lolium perenne* +, *Lotus corniculatus* +, *Plantago lanceolata* 1, *Poa trivialis* 1, *Polygala vulgaris* +, *Ranunculus acris* 2, *Rumex acetosa* 1, *Trifolium pratense* 1, *Veronica chamaedrys* +. Other: *Hieracium pilosella* +, *Holcus mollis* +, *Luzula campestris* 1, *Nardus stricta* +, *Pimpinella saxifraga* +, *Potentilla erecta* +, *Pteridium aquilinum* +°, *Ranunculus repens* +, *Rumex acetosella* +, *Rumex obtusifolius* +, *Secale cereale* +°, *Veronica officinalis* +, *Plagiomnium rostratum* +, *Rhitidiadelphus squarrosus* +, *Ceratodon purpureus* +.

4.3.8. Cultivated meadows

Fields on which mixtures of grass and the clover are grown have their species composition similar to that of semi-natural meadows, however the species domination structure is different. Moreover, such fields are characterized by a small admixture of weeds (the class Rudero-Secalietea). Synanthropic species are relatively numerous – in 8 relevés over 20 of them were noted – but they show decreased vitality, small frequency and degree of abundance. *Anthemis arvensis, Oxalis europaea* and *Veronica arvensis* are found relatively most often.

Cultivated meadows cover larger areas of the watershed than semi-natural ones. Fields with the domination of the clover (*Trifolium pratense*) or a single species of grass (*Lolium multiflorum, Dactylis glomerata* or *Holcus lanatus*) are found most frequently. Cultivated meadows, as well as fields, are not shown on the map because of yearly crop rotation.

4.3.9. Echinochloo-Setarietum

Root crops cover smaller areas in the watershed than corn fields (Table 3). Besides potatoes, mangel-wurzels and, sometimes, maize are grown. Cabbages, carrots and other vegetables are grown in gardens that are fairly scrupulously weeded. Table 2 shows weed species composition of 6 potato and 1 mangel-wurzel fields. Weed coverage is high (40–80%).

Table 3. A comprehensive table for arable field communities
Vt – Vicietum tetraspermae, ES – Echinochloo-Setarietum, other explanations as in Table 2

Community	Vt		ES	
Number of relevés	12		7	
	F	I	F	I
1	2		3	
Ch. Vicietum tetraspermae:				
Bromus secalinus	5	316	1	1
Vicia tetrasperma	2	1	•	–
Ch. Aperion spicae-venti:				
Apera spica-venti	11	1502	3	4
Vicia hirsuta	11	502	4	6
Aphanes arvensis	9	795	1	1
Scleranthus annuus	8	794	3	74
Vicia angustifolia	6	232	1	1
Ch. Centauretalia cyani:				
Centaurea cyanus	11	1209	7	220
Vicia villosa ssp. *varia*	7	128	•	–
Agrostemma githago	3	3	•	–
Odontites verna	3	3	•	–
Papaver rhoeas	3	3	•	–

1	2		3	
Ch. Echinochloo-Setarietum:				
Galingsoga parviflora	•	–	7	2359
Setaria viridis	•	–	6	327
Echinochloa crus-galli	•	–	4	76
Ch. Polygono-Chenopodion and Polygono-chenopodietalia:				
Chenopodium album	2	147	7	787
Polygonum lapathifolium	•	–	7	80
Polygonum persicaria	2	2	6	1001
Chenopodium polyspermum	•	–	2	73
Geranium dissectum	•	–	2	3
Veronica persica	1	1	2	3
Sonchus asper	•	–	1	1
Ch. Secali-Violetalia:				
Viola arvensis	12	1003	7	399
Anthemis arvensia	11	1316	7	716
Veronica arvensis	11	318	4	146
Myosotis arvensis	10	398	4	254
Mentha arvensis	8	419	6	3
Oxalis stricta	8	48	7	359
Spergula arvensis	7	259	5	147
Vicia sativa	7	47	3	4
Raphanus rephanistrum	7	6	7	399
Sonchus arvensis	7	6	2	73
Ch. Rudero-Secalietea:				
Galeopsis tetrahit	12	835	6	149
Stellaria media	11	585	7	1894
Capsella bursa-pastoris	7	233	7	1894
Polygonum hydropiper	7	273	6	646
Galeopsis bifida	7	47	2	3
Polygonum aviculare	5	4	4	6
Rumex obtusifolius	5	4	7	259
Cirsium arvense	4	189	1	1
Lapsana communis	4	44	1	1
Bilderdykia convolvulus	4	3	5	7
Stachys palustris	3	3	5	77
Matricaria perforata	3	3	2	3
Elymus repens	2	2	7	150
Poa annua	2	2	5	396
Others:				
Galium aparine	11	857	4	6
Achillea millefolium	11	9	3	74
Ranunculus repens	10	503	6	79

Table 3, continued

1	2		3	
Cerastium fontanum ssp. *triviale*	9	89	2	72
Trifolium repens	8	1314	•	–
Rumex acetosella	8	605	5	1001
Equisetum arvense	7	47	3	74
Stellaria graminea	7	6	1	1
Holcus mollis	6	150	•	–
Trifolium pratense	6	46	3	4
Juncus bufonius	5	190	•	–
Phleum pratense	5	25	•	–
Rumex crispus	5	4	•	–
Filaginella uliginosa	4	44	6	149
Plantago major ssp. *intermedia*	4	3	4	6
Taraxacum officinale	4	3	4	6
Leontodon hispidus	4	3	•	–
Lolium multiflorum	3	3	4	4
Rorippa sp.	3	3	2	3
Daucus carota	3	3	•	–
Lysimachia vulgaris	3	3	•	–
Prunella vulgaris	3	3	•	–
Avena sativa	1	1	3	4
Atriplex patula	1	1	2	3
Bidens tripartita	•	–	3	4

Sporadic species: Ch. Secali-Violetalia: *Anagallis arvensis* Vt, ES, *Alectorolophus major* Vt, *Convolvulus arvensis* Vt, *Valerianella dentata* ES. Ch. Rudero-Secalietea: *Chamomilla suaveolens* Vt, *Galeopsis speciosa* ES, *Buglossoides arvensis* ES, *Myosotis stricta* ES. Others: *Agrostis capillaris* Vt, *Arabidopsis thaliana* Vt, *Arenaria serpyllifolia* ES, *Campanula rapunculoides* Vt, *Cerastium arvense* Vt, *Cerastium glomeratum* Vt, *Dactylis glomerata* ES, *Equisetym sylvaticum* Vt, *Equisetum telmateia* Vt, *Euphorbia* sp. Vt, ES, *Festuca rubra* Vt, *Galeopsis pubescens* ES, *Geranium pusillum* Vt, ES, *Gypsophila muralis* Vt, *Hypericum perforatum* Vt, *Leontodon autumnalis* ES, *Leontodon* sp. Vt, *Leucanthemum vulgare* Vt, *Linaria vulgaris* Vt, *Lolium perenne* Vt, *Pimpinella saxifraga* Vt, *Plantago lanceolata* Vt, ES, *Pteridium aquilinum* Vt, *Ranunculus acris* Vt, *Rorippa sylvestris* Vt, *Rumex* x *crispus* ES, *Sagina procumbens* Vt, *Sisymbrium officinale* ES, *Symphytum officinale* ES, *Tussilago farfara* Vt, *Utrica dioica* ES, *Veronica chamaedrys* Vt.

4.3.10. Vicietum tetraspermae

This is the most common synanthropic community in the valley of Ratanica (Table 3). It develops in the fields of rye (*Secale cereale*), wheat (*Triticum aestivum*) and, more rarely, barley (*Hordeum vulgare*) and oats (*Avena sativa*). The vegetation is fairly diverse, however some species characteristic of this community are missing. Weed coverage ranges between 10 and 60 (80) percent. In barley fields, the coverage as high as 90% was occasionally recorded.

5. THE RELATIONSHIP BETWEEN PLANT COMMUNITIES AND HABITAT CONDITIONS

The assessment of fertility of the soils differentiated, based on "trophism values" of the species constituting a given community (Zarzycki 1984), is given in Table 4. Communities were arranged according to the weighted average of these values from the lowest to the highest one. This should reflect the increasing productive capacity of the habitats. Table 4 shows that all habitats of the watershed studied are within mesotrophic and eutrophic habitat range, i.e. both poor and very rich habitat communities are not found. Communities occurring on moist warp soils and silty-gley soils have the highest trophism coefficients.

Table 4. Indicator values of the communities trophism
(a – weighted average, b – modal value)

a	Community	b	Type of vegetation
3.05.	Pino-Quercetum typicum	3.0	forests
3.11.	Pino-Quercetum rubetosum hirti var. typicum	3.0	
3.19	Pino-Quercetum rubetosum var. Fagus sylvatica	3.0	
3.25.	Luzulo-Fagetum	3.0	
3.35.	Tilio-Carpinetum	3.0	
3.38.	Fagus sylvatica-Hedera helix	3.0	
3.41.	Festuca rubra-Agrostis tenuis	4.0	meadows and fields
3.61.	Vicietum tetraspermae	4.0	
3.69.	Echinochloo-Setarietum	4.0	
3.71.	Arrhenatheretum elatioris	4.0	
3.80.	Cirsietum rivularis	4.0	
3.87.	Carici remotae-Fraxinetum	4.0	alder-woods

Forests (apart from alder-ash woods) develop on poorer soils than anthropogenic communities. This division was marked especially when modal values (for trophism values distribution within a given syntaxon) were calculated. The value amounts to 4 for meadow and cultivated field communities and 3 for forests. It means that either almost all fertile habitats were cultivated, or the man activity has led to deterioration of forest habitats and eutrophication of the cultivated soils.

A comparison between the maps of soils and vegetation distribution aimed at the solution to this dilemma. However, the method employed in the analysis yielded a small number of data for communities covering small, dispersed sites, and, therefore, they were not very reliable. It concerned alder-ash woods (1 site), oak-hornbeam forests (5 sites), acidophilous beech woods (5 sites) and semi-natural meadows (5 and 7 sites). Nevertheless, relations between these communities and certain types of soil were confirmed in most instances. For example, all data for acidophilous beech woods have happened to belong to the same soil set – "podzolised brown and

podzolised lessive soils, fine sands and loamy fine sands". Distribution of thistle meadows (Cirsietum rivularis), that are ascribed a high trophism coefficient, coincides with the range of very fertile loamy warp soils.

A large majority of data, however, concern dominating habitats, and this allowed to employ the quantitative analysis of the results (Fig. 5). A share of certain soil types differs significantly between the three major groups of communities (deciduous forest, coniferous forest and cultivated fields). Sandy podzolised soils dominate in coniferous forests, but almost all loamy soils (acidophilous brown, leached brown, fine-sands and loamy fine-sands) are under cultivation. Over 80% of all crops grow on these most fertile soils, whereas their share in coniferous forests soil composition is insignificant (around 1.5%, and this may be a result of imprecision of the method). Therefore, the relationship between vegetation and the habitat fertility, suggested on the basis of indicator values analysis, was confirmed here.

A classification of soils given by Adamczyk et al. (1989) is based, among other things, on the type of the substratum, i.e. the property that rather does not change in the course of cultivation. We can, therefore, assume that almost all forest communities associated with more fertile soils were eliminated and replaced by anthropogenic vegetation. The soils of deciduous forest communities are more variable, which corresponds well with their greater floristic variability – in the diagram, records for communities representing 3 significantly different alliances (Alno-Padion, Carpinion betuli, Luzulo-Fagion) of the class Querco-Fagetea, were combined. The share of fine–sands and loamy fine-sands of the podzolised brown soils type was the largest. Comparing the diagrams one can see that existing (at present) fragments of deciduous forests develop on less fertile soils than arable field communities. Significantly eutrophic oak-hornbeam forest sub-communities are missing in the vegetation of the valley of Ratanica, and some of beech woods belong to the poorest deciduous forest community (Luzulo-Fagetum).

Many data for mixed forests allow further analysis of the soils of this community. A division into smaller units (Fig. 5) shows that Pino-Quercetum typicum has more features of the coniferous forest than both variants of Pino-Quercetum rubetosum hirti, 96% soils of this community belongs to podzolic or podzolised brown soils of mechanical composition of sandy soils and loamy-sands. In the bramble forest, more fertile soils have considerable share. It suggests that some stands developed in habitats formerly occupied by the high oak-hornbeam forest. This especially concerns the variant with the beech – the share of heavier, more fertile soils exceeds 40% there.

6. DISCUSSION

The study has shown that vegetation of the Ratanica watershed is typical of the Carpathian Foothills. All communities identified are widespread in the Wieliczka Foothills area, or common in the whole of southern Poland, for example,

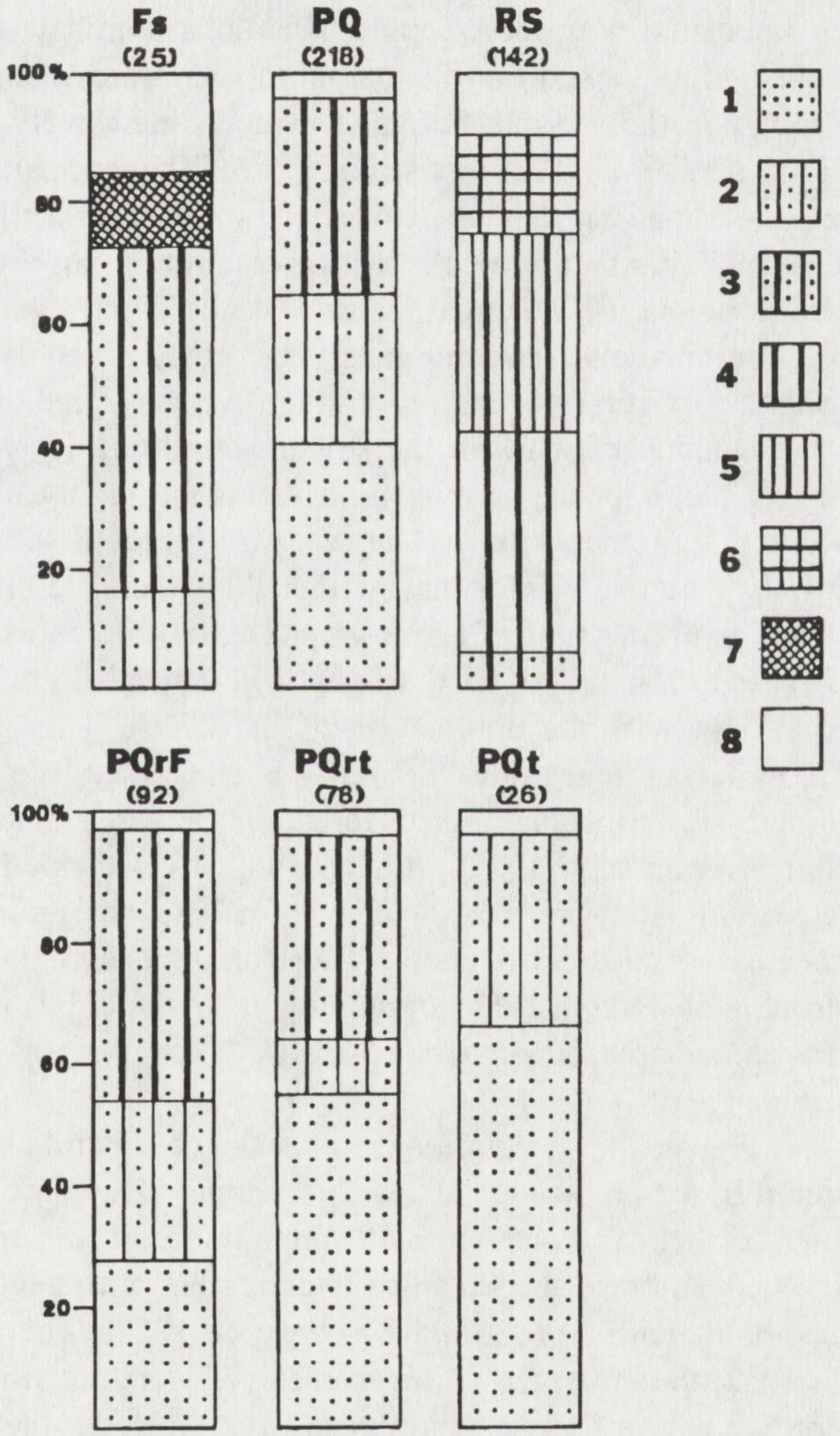

Fig. 5. The share of individual types and kinds of soils in dominating plant communities (the values in brackets denote the number of records for a given community; a group of communities)
Communities: Fs – Fagetalia sylvaticae (combined), PQ – Pino-Quercetum (combined), RS – Rudero-Secalietea, PQrF – Pino-Quercetum rubetosum var. Fagus sylvatica, PQrt – Pino-Quercetum rubetosum var. typicum, PQt – Pino-Quercetum typicum. Soils: 1 – podzolic soil and podzols, sands, 2 – podzolised brown soils, sands and sandy loams, 3 – podzolised brown and podzolised lessive soils, fine sands, 4 – acid brown soils, loams, 5 – leached brown soils, loams, 6 – pseudogleyed lessive soils, fine sands and fine sandy loams, 7 – deluvial and alluvial warp soils, loams and loamy fine sands, 8 – others

synanthropic communities. General features of their habitat requirements are also known (Trzcińska-Tacik et al. 1973, Dubiel and Trzcińska-Tacik 1984, Różański et al. 1987, Różański and Szwagrzyk 1987, Medwecka-Kornaś 1988, Medwecka-Kornaś et al. 1988).

Communities associated with mesotrophic, acid soils dominate in the landscape of the valley studied. The lack of fertile oak-hornbeam forests and beech woods which are often found in the Lessive Foothills even in intensively cultivated areas (Medwecka-Kornaś et al. 1988), is striking here. The comparison between the soil map and the vegetation map has shown that in some cases entire habitats were taken under cultivation. This fact carries a risk of committing an error if an attempt to predict the development of potential natural vegetation (Tüxen 1956) was undertaken. Some combinations (communities) that could possibly grow here are probably missing in the existing vegetation. Though we may predict what would be their position at the edaphic network in the soil moisture-fertility combination, any prediction concerning plant species composition would be highly uncertain. Taking into account habitat requirements of oak-hornbeam forests in other parts of the Foothills we can only tentatively infer that, within the watershed studied, cultivated fields usually replace poor and typical forms of oak-hornbeam forests.

The analysis (based on maps) of mixed forest soils revealed considerable habitat variability of the variant with the domination of the beech. This result was rather unexpected, since, as far as vegetation variability is concerned, the beech variant is the most homotonous form of the mixed forest in the area studied (Pancer-Kotejowa and Różański 1992). It seems that overshadowing of the forest floor by the beech dominating in tree-stand and (or) in undergrowth is the factor responsible for decreased species diversity. Therefore, the herb layer composition suggests a mesotrophic character of the community as a whole, but it does not reveal potential edaphic characteristics of some stands. This pattern may be of an anthropogenic origin.

Evaluation of the edaphic conditions of the communities by means of bioindication method based on ecological indicator values (Zarzycki 1984) seems to be, in principle, correct. The sequence of communities in the trophism gradient determined for the vegetation of the Ratanica is consistent with general diagnoses of these communities' habitats (Szafer and Zarzycki 1972). This consistence may result from the fact that the indicator values themselves were determined mainly (but not exclusively) on the basis of phytosociological data. However the typological map of soils, made independently, confirmed the results.

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7. SUMMARY

The watershed of the Ratanica is situated in the Flysh part of the Wieliczka Foothills (49°51'N; 20°02'E), within an altitude range of 270–424 m (Fig. 1). Its total area, after a reservoir on the Raba has been filled, amounts to 241.5 ha, and over a half of the area is covered by forest.

Tree-stand is dominated by the pine (introduced by man) and the beech (Table 1, Fig. 2). The latter shows considerable dynamics – it is represented in all volume classes and in older seedlings.

A share of the pine is small. Large timber volume per 1 ha (the whole tree-stand plus waste wood and undergrowth) and an average volume increment amount to 254 (302) m^3 ha^{-1} and 7.9 (9.7) m^3 ha^{-1} yr^{-1}, respectively. These values are relatively high, comparable to Carpathian lower montane forests.

12 plant communities were identified within the watershed area by means of the Braun-Blanquet method, and 10 out of them were classified as associations (see pp. 354–356). The relationship between vegetation and its habitat was analysed in two ways. In the first method, the trophism coefficient of a given community (Table 4) was calculated as a weighted average of trophism values (Zarzycki 1984) of all species constituting the community. In the second method, the map of vegetation (Fig. 4) was compared with the map of soils (Adamczyk et al. 1989) by projecting on both of them the grid of over 403 points in a systematic-random system. It enabled us to assess variability of soil units within individual communities (Fig. 5).

The vegetation map (Fig. 4) presents spatial distribution of communities. The Pino-Quercetum mixed forest (Table 2) and arable fields communities, Vicietum tetraspermae and Echinochloo-Setarietum dominate in the vegetation (Table 3). Fodder crops (grass, clover) are also common. Their composition is similar to meadow vegetation with an admixture of synanthropic plant species. Other communities, both forests and meadows, occur as small fragments (examplary relevés are given in the text).

The Pino-Quercetum mixed forest occurs in various forms: apart from a typical association, a sub-association specific to the Carpathian Foothills, P. Q. rubetosum hirti (Różański et al. 1987), is also found. The latter forms two distinct variants: the typical one and the one with the domination of the beech. Some of mixed forests with the bramble (*Rubus hirtus* W.K.) probably developed, as considerable soil variation suggests, in deteriorated oak-hornbeam forest sites (Fig. 5).

Both ecological indicator values (trophism values) of plant species (Table 4) and soil characteristics given by Adamczyk et al. (1989) allowed to classify the watershed's habitats as mesotrophic and moderately eutrophic. Trophism values (averages for each community) allowed to arrange syntaxa in sequence from the ones overgrowing moderately poor soils to the ones growing on rich soils. The modal values of trophism values distribution bring out differences between habitats of the groups of communities. Apart from alder-ash woods, all forest communities (even of the order Fagetalia) cover poorer soils than meadows and arable fields.

The analysis of the share of individual types and kinds of soils in habitats of dominating communities (Fig. 5) confirmed the above results. The poorest soils – sandy, of podzolised soils group – are covered by a typical mixed forest sub-association (Pino-Quercetum typicum). Sub-association with the bramble (P.Q. rubetosum hirti) grows on more variable soils, with a large share of podzolised brown and loamy soils and fine-sands. It probably covers partly the sites of poor oak-hornbeam forests.

All most fertile habitats – leached and podzolised brown soils, loamy soils and fine-sands are covered by arable and fodder-crop fields. The only exceptions are very moist warp and silt soils, on part of which alder-ash wood vegetation was left, the rest being taken under semi-natural, mowed meadows (the Calthion alliance) cultivation.

The validity of determining the potential natural vegetation for the area studied is discussed.

8. POLISH SUMMARY

Zlewnia potoku Ratanica leży w obrębie fliszowej części Pogórza Wielickiego (49°51'N, 20°02'E) w pasie wysokości 270–424 m n.p.m. (rys. 1). Jej powierzchnia, po wypełnieniu zbiornika zaporowego na Rabie liczy 241,5 ha, z tego prawie połowę zajmuje zwarty kompleks leśny.

W drzewostanach dominują sosna (z nasadzeń) oraz buk (tab. 1, rys. 2), który wykazuje znaczną dynamikę – jest reprezentowany we wszystkich klasach grubości drzew (rys. 3) i w nalotach. Udział jodły jest niewielki. Zasobność grubizny drzewostanów (całości drzewostanów z drobnicą i podszytem) wynosi średnio 254 (302) m^3 ha^{-1} oraz odpowiednio średni przyrost miąższości 7,9 (9,7) m^3 ha^{-1} r^{-1}.

Są to wartości stosunkowo duże porównywalne z przeciętną zasobności i przyrostem dolnoreglowych lasów karpackich.

Na terenie zlewni wyróżniono metodą Braun-Blanqueta 12 zbiorowisk; 10 w randze zespołów (p. 354–356). Związek między roślinnością a siedliskiem przeanalizowano na 2 sposoby. W pierwszym określono wskaźnik trofizmu zbiorowiska (tab. 4) obliczony jako średnia arytmetyczna liczb trofizmu (Zarzycki 1984) poszczególnych gatunków wchodzących w skład fitocenozy. W drugim porównano mapę roślinności (rys. 4) z mapą gleb (Adamczyk i in. 1989) przez narzucenie na obie mapy sieci ponad 403 punktów w układzie systematyczno-losowym, co umożliwiło przybliżoną ocenę zmienności jednostek glebowych w obrębie poszczególnych zbiorowisk (rys. 5).

Układ przestrzenny zbiorowisk przedstawia mapa roślinności (rys. 4). Dominującym zespołem jest bór mieszany Pino-Quercetum (tab. 2) oraz zespoły pól uprawnych Vicietum tetraspermae i Echinochloo-Setarietum (tab. 3). Ponadto częste są uprawy pastewne (trawy, koniczyny), których skład florystyczny przypomina roślinność łąkową z domieszką roślin synantropijnych. Pozostałe zespoły, zarówno leśne jak i łąkowe występują w postaci niewielkich fragmentów (przykładowe zdjęcia fitosocjologiczne umieszczono w obrębie tekstu).

Bór mieszany Pino-Quercetum jest wewnętrznie zróżnicowany: oprócz podzespołu typowego występuje specyficzny dla Pogórza podzespół P. Q. rubetosum hirti (Różański i in. 1987). Podzespół ten w dol. Ratanicy zróżnicowany jest na dwa wyraźne warianty – typowy oraz z panującym bukiem. Bory mieszane z jeżyną prawdopodobnie po części rozwinęły się na siedliskach zdegradowanych grądów, na co wskazuje zróżnicowanie gleb (rys. 5).

Zarówno ekologiczne liczby wskaźnikowe (trofizmu) gatunków roślin (tab. 1), jak charakterystyka gleb podana przez Adamczyka i in. (1989) pozwalają określić siedliska zlewni jako mezotroficzne i średnio zasobne. Liczby trofizmu – średnie dla każdego zbiorowiska – porządkują wyróżnione syntaksony od zajmujących gleby umiarkowanie ubogie aż po wykształcone na glebach zasobnych, wartości modalne rozkładów tych liczb uwydatniają natomiast różnicę między siedliskami grup zbiorowisk. Oprócz lasów łęgowych wszystkie zbiorowiska leśne (nawet z rzędu Fagetalia) zajmują gleby uboższe w porównaniu z siedliskami pól uprawnych i łąk.

Analiza udziału poszczególnych typów i rodzajów gleb w obrębie panujących zespołów (rys. 5) potwierdziła ten wynik. Najuboższe gleby – piaszczyste, w typie gleb bielicowych – zajmuje podzespół typowy boru mieszanego (Pino-Quercetum typicum). Podzespół z jeżyną (P. Q. rubetosum hirti) ma gleby bardziej zróżnicowane, ze znacznym udziałem gleb brynatnych bielicowanych, gliniastych i pyłowych. Prawdopodobnie zajmuje on częściowo siedliska ubogich grądów.

Wszystkie najżyźniejsze siedliska – gleby brunatne wyługowane oraz płowe, gliniaste i pyłowe zajmują pola uprawne i uprawy pastewne. Wyjątek stanowią tylko bardzo wilgotne mady i gleby mułowe, na których po części pozostawiono leśną roślinność łęgową, po części zaś zajęto pod półnaturalne wilgotne łąki kośne (związek Calthion).

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