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CONTENTS

1. INTRODUCTION

Areas for which early phytosociological documentation exists, are particularly suitable for estimation of vegetation changes. This is also true for the Ojcow National Park (ONP), located in southern Poland, about 22 km NNW of Cracow (Fig. 1).

The plant communities of this area have been mapped about 30 years ago (MEDWECKA-KORNAS and KORNAS 1963). Apart from the published data also some unpublished materials from the 1950-ties have been preserved, which were now taken into consideration.

Our paper deals with the acidophilous mixed forest association *Pino-Querce-*

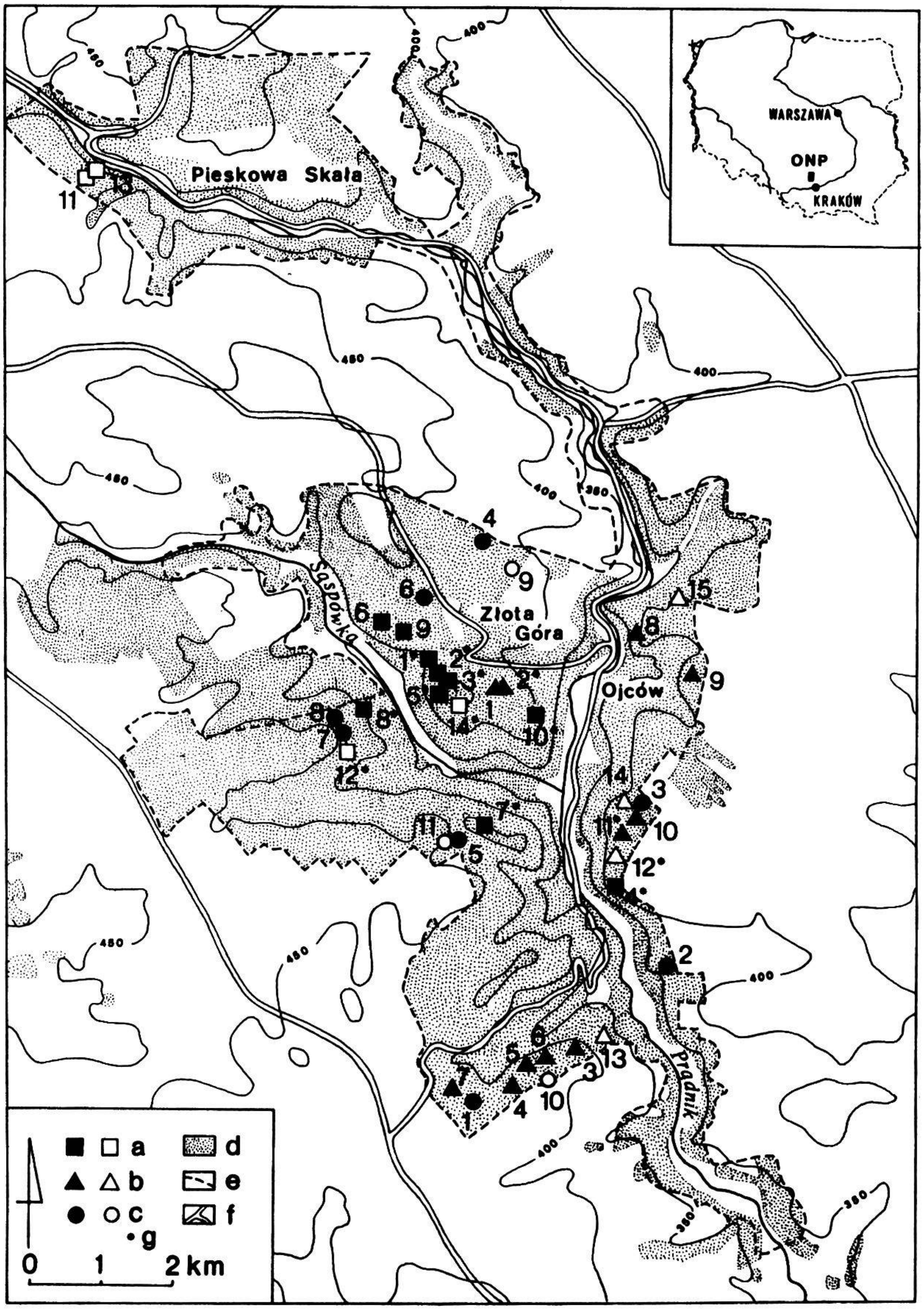

Fig. 1. Distribution of phytosociological records of acidophilous mixed forests *Pino-Quercetum* in the Ojcow National Park. Record numbers as in Table 3-5.
Solid symbols: 1958-59 records; repeated in 1986-88, open symbols: additional records from 1986-88; g - records in strict reserves; a - *Fagus sylvatica* variant; b - *Abies alba* variant; c - *Pinus sylvestris* variant; d - forests; e - Park borders; f - roads.

tum Kozl. 1925 in which more distinct transformations occurred than in any other forest community in the study area. They resulted from the mass-dying of coniferous trees, mainly the silver fir, *Abies alba*, and the Scots pine, *Pinus sylvestris*. Short reports on these events were already published (ZABECKI 1984, MEDWECKA-KORNAS and GAWRONSKI 1990). Now we present the phytosociological tables with complete field records from the years 1958-59 and 1986-88 and a discussion based on pedological data and numerical indicator values, especially those of ELLENBERG (1974).
Nomenclature of taxa follows TUTIN et al. (1964-1980) for vascular plants and OCHYRA and SZMAJDA (1978) for mosses.

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2. ENVIRONMENTAL CONDITIONS IN THE ONP

The Ojcow National Park includes the valley of rivulet Pradnik, deeply incised in jurassic limestones and surrounded by a gently rolling plateau. The relief of the Park is highly varied. The local flora consists of about 950 species of vascular plants, and the vegetation is composed of epilithic xerothermic grasslands, meadows, shrub thickets and various types of forests, mainly neutrophilous ones. Mixed forests of coniferous and deciduous trees (*Pino-Quercetum*) form the sole acidophilous forest association in the ONP (MEDWECKA-KORNAS and KORNAS 1963).
In 1960-70 a rapid decrease of vitality of coniferous trees became evident in the forests of the ONP, followed by their mass-dying and an accumulation of dead organic matter on the forest ground (KAMIENIECKI and SZCZESNY 1972). The main factor responsible for these processes seems to be the increase of air pollution originating in the near-by urban and industrial centres of Silesia, the coal power station in Siersza, the lead-zinc smelting works near Olkusz and the city of Cracow. The distant sources of pollution in the eastern part of Germany and in Czechoslovakia also contributed to the worsening of the situation (RYSZKOWSKI and BALAZY 1988). The pollutants were transported to the Park mainly by the dominant western winds.
The average yearly SO_2 concentration in 1977-85 ranged in the Park from 55.0 $\mu g/m^3/24$ hours to 91.9 $\mu g/m^3/24$ hours (JUSZKIEWICZ and PARTYKA

1987), the permissible concentration in protected areas according to the Polish norms - being 75 $\mu g/m^3/24$ hours. The mean monthly values of SO_2 content were higher in winter than in summer and reached 200% or more of the permissible concentration. The short term concentrations were sometimes very high (JUSZKIEWICZ and PARTYKA 1987). As demonstrated by the forest monitoring system, organized by the Institute of Forest Research in Warsaw, the mean atmospheric SO_2 concentrations in the Ojcow National Park (estimated as 31.4 $mg/m^2/24$ hours in 1987/88) were about twice as high as in the Bialowieza National Park located in a relatively clean area of northeastern Poland. The concentrations of fluorine and NO_2 (0.12 and 0.72 $mg/m^2/24$ hours, respectively) were about 10 times higher than in Bialowieza (data for 1987/88). Dust fall in some parts of the ONP exceeded now and then 100 t/km^2/year (the admissible norm for protected area being 40 t/km^2/year). In 1982 when industrial activity was markedly lowered, the dust fall in the ONP was estimated as 51.3 t/km^2/year (MANECKI et al. 1988). The slightly soluble in water fraction amounted to 78.1%; as major components were identified quartz and silicate glass, as minor component e.g. gypsum, and as trace components e.g. dolomite and calcite (silicate glass and gypsum being of industrial origin). The amount of heavy metal deposition (in kg/km^2/year) was: Fe 1202, Zn 116.8, Mn 29.1, Pb 22.4, Cu 9.2, Ni 8.9. Zinc was found in the form highly soluble in water. The precipitations were not extremely acid, because of their neutralization by dust. Their pH was on an average 4.7 in winter and 5.3 in summer; the mean monthly values ranged from pH 3.9 (January 1989) to pH 5.9 (April 1988) (ZAJAC et al. in print). It is worthy of note that in non-polluted areas the pH of 5.6-6.0 in atmospheric precipitations is considered to be natural (SMITH 1981).

The degree of air pollution in the ONP was characterized also by means of bioindication (GRODZINSKA 1980, KAZMIERCZAKOWA et al. 1984) and by soil analyses in an exemplary stand of mature mixed forest (*Pino-Quercetum*) on the plateau (SWIEBODA 1980). The results of these analyses for the 4-14 cm soil horizon were (in p.p.m.): S: 80, Zn: 340, Pb: 85, Cr: 44, V: 21, Ni: 10, Co: 9, Cu: 6. Concentrations of sulphur, zinc and lead were many times higher than in a control plot, and those of zinc approached the values toxic for plants. These estimations were made around 1970, when the injuries to pines were not yet visible.

The local distribution of pollutants in the ONP is uneven because of the highly varied relief. This was confirmed by direct measurements and the "bark test" of HÄRTEL and GRILL (1972), which consists in measuring the electrolytic conductivity and sulphate concentration in water extracts. It was applied to the bark of *Pinus sylvestris* in the ONP by MEDWECKA-KORNAS et al. (1989).

3. METHODS OF INVESTIGATIONS

Vegetation. In the phytosociological investigations both thirty years ago and at present, the method of BRAUN-BLANQUET (1964) was used. The number of records available was limited by the relatively small area of the ONP (about 1500 ha) and by the scarcity of *Pino-Quercetum* stands. The sites of the former records have been located with the help of the map of their distribution 1:10'000 and the field notes from 1958-59. Only in few cases the localization of the former study plots was uncertain. Due to disturbances some areas of the repeated record were smaller than the original ones. For complementary information new records were made in forest stands not studied in 1958-59, but still containing a number of species typical of *Pino-Quercetum.* These records are placed in the last columns in the Tables 3-5. The individual syntaxonomic groups are numbered in the tables with Roman numerals, which are used also in the lists of sporadic species. The following abbreviations are used for the vegetation layers: a - tree layer, b - shrub layer, c - ground (herb and moss) layer.

Soil. The soil characteristic of the *Pino-Quercetum* stands was based on examination of twelve soil profiles distributed by four in each variant of this association. The pits were 70-80 cm deep and were dug in October 1989. In the soil samples the following values were measured: pH (potentiometrically), organic carbon (by the method of Turin), total nitrogen (by the method of Kjeldahl), assimilable K_2O and P_2O_5 (by the method of Egner-Riehm) and CaO (with flame photometer). The granulometric composition of the soil was determined by the method of Casagrande modified by Proszynski.

4. SOME FEATURES OF *PINO-QUERCETUM* AND ITS SOIL CONDITIONS IN THE ONP

The delimitation and syntaxonomical position of *Pino-Qercetum* (= *Quercetum medioeuropaeum* MEDWECKA-KORNAS 1952) accepted in the present paper is that of the earlier papers on the vegetation of the ONP (MEDWECKA-KORNAS and KORNAS 1963) as well as of numerous other Polish publications (cfr. MEDWECKA-KORNAS et al. 1966). The stands of *Pino-Quercetum* cover about 37% of the Park area, more than any other plant community. They be-long to the subassociation *P.-Q. luzuletosum* and are differentiated into three variants. The *Fagus sylvatica* variant occurs mainly in the transition belt between valley slopes and the plateau and covers about 4% of the Park area. The *Abies alba* variant and the *Pinus sylvestris* variant are developed mainly on the plateau. They occupy about 5% and 28% of the Park area, respectively. High share of Scots pine in the forests of the ONP results mainly from it being planted on abandoned fields and forest clearings, resulting from the intensive forest exploitation at the end of the 19th and the beginning of the 20th centuries, before the establishment of the National Park in 1957 (MICHALIK 1974).

The soils in *Pino-Quercetum* of the ONP developed in Quaternary loess deposits. They are deep in the *Abies* and *Pinus* variants, but relatively shallow in the *Fagus* variant. In two of the four profiles studied in the *Fagus* variant calcareous boulders and the underlying calcareous rocks were found already in the depth of 40 cm and 75 cm, respectively. The litter layer measured in most cases 2-5 cm, and the zone of litter humification (A_{0f}) was distinct, but shallow (1-2 cm). The mineral humus horizon (A_1), dark grey or black, measured 2-6-(8) cm. In some profiles a thin A_{1+3} horizon, with slightly lightened patches, was observed. The deeper horizon (A_3/B_t) showed traces of leaching and formed a transgression zone to the deeper, textural and more or less compact B_t/C (or B_t/D) horizon, usually extending down below the pit depth (GRESZTA and BITKA 1977, MEDWECKA-KORNAS 1952). The colour of soil (excepted the humic layers) was yellow, and the granulometric composition in near all samples was that of silty loam (Table 1). The results of chemical analyses are presented as mean values calculated separately for groups of four profiles in each variant of the association (Table 2). A similar range of variability was found for the C/N ratio in the A_1 horizon in the *Fagus* variant (from 1:11-1:23), the *Abies* variant (1:10-1:23) and the *Pinus* variant (1:10-1:24). In half of the stands it did not exceed 1:16. The soil reaction was always acid, with the exception of the B_t/D horizon in the *Fagus sylvatica* variant, where it was directly influenced by the calcareous bed-rock. The pH values (in H_2O) of the litter horizon (A_{0f}) were similar to those of the humic-mineral horizon (A_1) and ranged from 3.8 in some samples of the *Abies* and *Pinus* variants to 5.2 in the *Fagus* variant. The pH of the upper soil layers was slightly lower than that of the deeper layers. The contents of assimilable potassium and phosphorus of the soil ranged from 6.4-66.4 mg/100 g and 1.7-18.0 mg/100 g, respectively, with marked differences between individual profiles and their particular horizons. In several cases they attained their

Table 1. Granulometric composition of soil (mean values of four profiles in each of the three variants of *Pino-Quercetum).*

Horizon	Depth (cm)	Fraction content (%) mm					
		1-0.1	0.1-0.05	0.05-0.02	0.02-0.005	0.005-0.002	<0.002
				***Fagus sylvatica* variant**			
A_1	2-4(8)	15.7	16.7	35.0	19.3	5.0	8.3
A_{1+3}	4-10	10.3	17.0	30.3	23.0	9.0	10.3
A_3/B_t	10-40	10.8	10.9	40.0	19.7	10.1	8.5
$B_t/C/D$	40	11.7	13.2	37.0	23.2	4.5	10.2
				***Abies alba* variant**			
A_1	2-5(8)	24.3	19.8	29.2	14.8	2.7	9.2
A_{1+3}	5-9	7.5	9.5	38.0	23.5	12.5	9.0
A_3/B_t	9-40	5.7	12.2	45.8	21.0	7.8	7.5
B_t/C	40-80	6.0	10.5	41.0	22.5	4.3	15.7
				***Pinus sylvestris* variant**			
A_1	2-6	17.3	21.0	32.7	15.0	6.0	8.0
A_3/B_t	6-40	5.8	10.3	41.6	24.5	8.2	9.6
B_t/C	40-75	5.0	9.5	37.0	25.7	8.2	14.5

minimum in upper leached soil horizons (A_{1+3} or A_3/B_t). The distribution of assimilable calcium was similar. The hydrogen ions in the absorbing complex exceeded (with few exceptions of the B_t/D horizons) the sum of the exchangeable cations. The degree of V-saturation was generally rather low (in the A_1 horizon: 14.4-42.1 in the *Fagus* variant, 12.5-13.8% in the *Abies* variant, 12.5-58.2% in the *Pinus* variant). The decrease of the V-values in the A_{1+3} or A_3/B horizons, in relation to C (or D), was a rule. As proved by these characters, the soils of the *Pino-Quercetum* association in the ONP represent the type of Haplic Lurisols (FAO-UNESCO 1988) or of "soil lessivé" (leached soil) developed in loess (KROLIKOWSKI et al. 1986, GRESZTA and BITKA 1977). According to this classification used in Poland they have to be regarded as intermediate between the subtypes of proper leached soils and slightly podzolized leached soils, in some stands being closer to the first of those subtypes, and in others to the second one. The differences between individual profiles, however, were of a minor rank, and no correlation has been discovered between them and the differentiation of the *Pino-Quercetum* vegetation.

Table 2. Chemical soil properties in the stands of *Pino-Quercetum* in the Ojcow National Park (mean values for four profiles in each variant).
Analyses of the A_{1+3} horizon concern three profiles in the *Fagus sylvatica* variant and two profiles in the *Abies alba* variant.

Genetic horizons	Depth cm	Organic C %	Organic matter in %	Total N in %	C/N	pH in H_2O	pH in KCl	Assimilable K_2O mg/100 g of soil	Assimilable P_2O_5 mg/100 g of soil	Assimilable CaO mg/100 g of soil	Absorbing complex H miliequiv. per 100 g of soil	S	T	V in % (S/Tx100)
***Fagus sylvatica* variant**														
A_1	2-4(8)	5.29	9.13	0.396	15.9	4.7	3.9	11.8	3.0	197.0	17.9	6.2	24.1	25.3
A_{1+3}	4-10	2.95	5.08	0.208	16.3	4.8	3.7	8.8	5.3	164.3	13.4	6.2	19.6	28.3
A_3/B_t	10-40	0.96	1.66	0.053	18.4	4.7	3.8	6.9	2.2	67.2	9.3	3.9	13.2	26.6
$B_t/C(D)$	>40	0.61	1.06	0.041	15.6	5.6	4.5	9.5	2.9	286.3	5.3	9.5	16.2	56.3
***Abies alba* variant**														
A_1	2-5(8)	9.33	16.09	0.567	17.7	4.0	3.4	32.0	10.6	70.0	38.8	5.2	41.0	13.0
A_{1+3}	5-9	1.78	3.08	0.113	15.6	3.6	3.3	7.4	3.5	13.7	12.0	3.9	15.9	24.4
A_3/B_t	9-40	0.41	0.71	0.036	11.6	4.3	3.9	12.8	5.8	6.6	5.9	2.2	8.2	27.7
B_t/C	40-80	0.23	0.40	0.012	13.2	4.5	3.9	11.8	4.4	32.5	7.8	4.3	12.1	36.3
***Pinus sylvestris* variant**														
A_1	2-6	7.86	13.54	0.447	16.5	4.2	3.6	14.2	6.3	84.3	23.6	5.6	29.2	28.1
A_3/B_t	6-40	0.46	0.80	0.048	10.3	4.5	4.0	9.1	4.0	11.6	7.4	3.0	9.2	32.8
B_t/C	40-75	0.20	0.35	traces	--	4.7	3.9	12.3	4.3	66.3	6.8	5.9	12.8	43.1

5. CHANGES IN STRUCTURE AND FLORISTIC COMPOSITION IN THE STANDS OF *PINO-QUERCETUM*

The dimensions of changes in the *Pino-Quercetum* stands were assessed by comparison of the state in 1958-59 and the present one (Tables 3, 4, 5). All vegetation layers were taken into consideration. The changes were not quite the same in the particular variants, and clearly depended on both, the location of the stand and the kind and intensity of the interference of forest-rangers, carried out especially outside of the strict reserves.

a) Tree layer. The mean height of trees (estimated visually) increased in majority of stands, but decreased (due to the death of individual trees or tree-felling) in some others. In partial reserves some of the weakened trees have been removed to prevent the outbreak of noxious insects present in the Park (CAPECKI and TUTEJA 1977). These events influenced more or less the canopy structure. Its changes were most limited in the *Fagus* variant: the canopy cover remained as high as thirty years ago (75-90%). In the *Abies* and *Pinus* variants the cover of the upper tree layer (a_1) decreased as a rule because of the dieback of conifers. In many stands, however, deciduous trees, mainly beech, filled in the gaps or formed a lower tree layer (a_2). This is clearly reflected by the decrease of mean abundance values for fir and Scots pine and its increase for deciduous species (Table 6). Due to this course of events, damage in tree layer not always resulted in an increase of the amount of light inside the forest stands studied. The decrease of vitality of trees (marked by a zero exponent "^{o}" in the records) and even their dieback are not expressed clearly enough in the phytosociological tables. Therefore the standard procedure has to be supplemented by additional particulars, as those presented by MEDWECKA-KORNAS and GAWRONSKI (1990), who distinguished various degrees of damage in fir trees on the study plots, as used in the Table 7 of the present paper.

b) Shrub layer. Similarly to the tree layer, the share of conifers in the undergrowth also decreased. In the case of *Pinus sylvestris* no regeneration was observed. The share of *Sorbus aucuparia* remained unchanged. *Sambucus nigra* and *S. racemosa* expanded considerably (especially in the *Abies* variant), and they occur now in many places, from which they were absent about thirty years ago.

Table 3. *Pino-Quercetum luzuletosum, Fagus sylvatica* variant.

Years of records		1958-1959														1987-1988										Presence degree in records		
Successive number		1	2	3	4	5	6	7	8	9	10	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11	12	13	14			
Altitude (m)		410	410	420	418	415	416	450	400	412	410	410	410	420	418	415	416	450	400	412	410	398	443	398	437			
Exposure		W	SW	W	W	SW	SWS	NE	NE	SWS	SES	W	SW	W	W	SW	SWS	NE	NE	SWS	SES	S	ES	NEN	W			
Slope degree (°)		5	5	25	20	20	15	5	10	5	15	5	5	25	20	20	15	5	10	5	15	10	10	5	15			
Mean height of trees (m)		20	22	23	17	25	-	26	22	25	23	25	25	25	18	27	26	30	27	26	25	30	18	27	25			
Canopy cover (%)	a	85	85	90	85	75	85	80	75	75	80	90	90	95	85	90	95	75	90	80	80	65	60	90	90			
Undergrowth cover (%)	b	5	5	30	30	10	40	20	65	60	5	5	10	10	35	15	5	30	30	15	5	15	25	15	5			
Ground layer cover (%)	c	85	75	60	70	60	40	70	65	60	50	70	60	70	60	55	15	50	15	30	60	80	70	80	40	1	1'	1'
Bryophytes cover (%)	d	15	15	20	30	30	20	5	5	10	2	10	5	10	5	5	2	2	2	2	2	10	5	2	10			
Area of sample plot (m^2)		150	150	200	250	200	400	300	400	350	250	150	150	150	100	200	400	300	400	350	200	200	300	100	100	10	10'	14
Trees																												
V *Abies alba*	a	.	.	.	.	+	2.2	2.1	2.2	4.3	4.4	.	.	.	.	+°	+°	2.2°	1.1°	2.2	3.3	.	2.2	.	+°			
	b	+°	1.1°	2.2	2.3	1.1°	3.2	2.1	4.3	+	1.2	.	+	.	2.2	.	+°	2.3	2.2	.	1.1	1.1	1.2	2.2	.	V	V	V
	c	1.1	1.1°	1.1	+	+	+	1.1	1.1	1.1	1.1	+	+	+	+	+	+°	1.1	+	+	+	+	+	.	+			
IV *Carpinus betulus*	a	.	.	.	.	.	1.1	.	+	.	+	.	.	.	.	.	+	.	+	1.1	+	.	.	.	.			
	b	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	V	III	II
	c	.	+	+	.	+	+	.	+	+	+	.	.	.	.	.	+	.	+	+	.	.	.	.	.			
V *Fagus sylvatica*	a	5.4	5.5	5.4	4.4	4.4	4.3	4.3	4.4	3.2	1.1	5.4	5.5	5.5	5.4	4.4	5.5	4.4	5.5	4.3	3.3	2.3	2.2	5.4	5.5			
	b	+	+	+	1.1	.	+	+	2.1	3.3	+	+	1.1	+	2.2	+	+	1.1	1.1	2.1	+	+.2	1.1	.	+	V	V	V
	c	+	+	1.1	1.1	+	+	+	1.1	.	+	+	1.1	1.1	1.1	+	+	2.2	+	+	1.1	1.1	2.2	1.1	+			
IV *Acer pseudoplatanus*	b	.	.	+	.	1.1	.	.	.	1.1	.	1.1	+	.	.	1.1	.	.	.	.	+	.	1.1	.	.	IV	V	V
	c	+	+	+	.	2.1	+	.	+	+	.	+	+	2.2	+	1.1	+	+	+	+	1.1	.	.	.	+			
II *Picea abies*	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	.	+	.			
	b	+	.	.	+	.	.	.	1.1	.	+	.	.	.	.	.	.	+	+	.	+	+	1.2	+	.	IV	III	III
	c	.	.	.	.	+°	.	+	.	+	.	.	.	+	.	.	.	.	+	.	.	+	+	.	.			
V *Quercus petraea*	a	.	.	.	+	.	.	.	.	.	+	.	.	.	+°	.	.	.	.	.	+	.	.	.	.			
	b	.	.	.	+	.	.	+	.	.	.	.	.	.	+°	.	.	.	.	.	.	.	.	.	.	IV	III	II
	c	+	.	.	+	+	+	.	+	+	.	+	.	.	+	+	.	.	+	.	.	.	.	.	.			
V *Betula pendula*	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	1.1	.	+	.	III	II	II
	b	+	.	+	.	+	.	+	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.			
V *Pinus sylvestris*	a	.	.	.	2.1	+	.	3.2	+	.	1.1	.	.	.	1.2	+°	.	2.2°	.	.	1.1	.	2.3	1.1	.	III	II	III
	b	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.			
IV *Acer platanoides*	c	.	.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Quercus robur*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	+	.	II	I	II
	c	+	+	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.			
IV *Tilia platyphyllos*	b	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	II	II	II
	c	.	+	+	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.			
IV *Fraxinus excelsior*	b	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	II	II
	c	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.			
I *Populus tremula*	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2.3	.	1.2	.			
	b	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	II
	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1.1	.	1.1	.			

Table 3 (continued)

Successive number		1	2	3	4	5	6	7	8	9	10	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11	12	13	14			
Shrubs																												
III *Sorbus aucuparia*	b	1.1	1.1	2.2	+	+	.	1.1	+	1.1	+	1.1	2.2	1.1	+	1.1	.	1.1	.	+	.	.	.	+.2	+	V	V	V
	c	1.1	1.1	2.1	+	1.1	+	1.1	+	+	+	1.1	2.2	1.1	+	+	+	1.1	+	+	+	+.2	+	1.1	1.1			
IV *Corylus avellana*	b	.	.	.	+	.	2.1	.	.	1.1	.	+	+.2	.	.	+	.	.	.	.	.	.	.	.	.	IV	IV	III
	c	.	+	+	+	+	.	.	+	.	+	.	+	.	+	.	+	.	.	+	+	.	.	.	.			
V *Frangula alnus*	b	+	.	.	.	.	.	.	+	.	.	+	1.1	+	+	.	.	+	.	.	.	.	+.2	+	.	IV	III	III
	c	.	.	+	+	+	+	.	+	+	.	.	.	.	.	+	.	+	.	.	.	.	+	+.2	.			
IV *Lonicera xylostemum*	b	+	+	.	.	.	.	.	.	+	.	1.2	+	.	.	+	.	.	.	+	.	.	.	.	.	IV	III	III
	c	.	.	+	+	+	+	.	.	.	.	+.2	.	.	+	+	+	.	.	+	.	.	.	.	.			
IV *Evonymus verrucosus*	b	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	I	I
	c	+	+	+	+	.	+	.	.	.	.	+.2	.	.	+	.	.	.	.	.	.	.	.	.	.			
IV *Viburnum opulus*	b	.	.	+	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	III	II	II
	c	.	.	.	.	+	+	.	.	+	+	.	.	+	.	+	.	.	+	.	.	.	.	.	.			
IV *Daphne mezereum*	c	.	.	+	.	+	.	.	.	+	.	+.2	.	.	.	1.1	.	.	.	.	.	.	.	.	.	II	I	I
IV *Rhamnus catharticus*	b	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
	c	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
IV *Ribes uva-crispa*	c	.	.	.	.	+	+	.	.	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	II	I	I
V *Rubus idaeus*	b	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	II	III
	c	.	+	.	.	.	.	+	+	.	+	+.2	+	.	.	.	.	+	.	+	.	.	1.1	+	+			
V *Sambucus nigra*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	-	III	III
	c	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	+	+	.	.	+			
Ground layer																												
I *Ch. Pino-Quercetum* (ˣloc.), *Pino-Quercion*																												
ˣ*Luzula luzuloides*		1.1	2.2	1.1	2.2	1.2	1.2	3.3	2.2	1.1	2.2	2.3	1.2	3.3	2.2	1.2	1.1	1.2	1.2	+.2	1.1	+	1.2	.	2.2	V	V	V
Veronica officinalis		.	+	+	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	IV	-	I
Genista germanica		.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	-	-
ˣ*Hieracium vulgatum*		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	-	-
ˣ*Hieracium sabaudum*		.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	-	-
II *Ch. Vaccinio-Piceetalia*																												
Orthilia secunda		+	1.2	+	+	+	+.2	+	+	+	+.2	.	.	.	+.2	+.2	.	.	.	+.2	.	.	2.2	.	.	V	II	II
Vaccinium myrtillus		4.4	3.3	3.3	4.3	4.3	2.2	4.4	3.3	3.2	3.3	3.3	3.3	2.2	3.2°	1.1	1.1	2.2	1.1	+	1.1	4.4	3.3	4.4	1.1	V	V	V
Pyrola minor		.	.	+	.	.	.	+.2	+	+.2	+	.	+.2	.	.	.	.	+	.	+	+.2	.	+	.	1.1	III	III	III
III *Ch. Vaccinio-Piceetea*																												
Maianthemum bifolium		1.1	1.1	1.1	1.1	2.2	2.2	2.1	2.1	2.2	2.2	1.2	2.2	1.1	.	1.2	2.1	1.1	1.1	1.1	+.2	+	1.1	+	1.1	V	V	V
Solidago virgaurea		1.1	1.1	+	+	+	+	.	.	+	.	+.2	1.1	+	+	+	.	.	.	+	.	.	.	.	+	IV	III	III
IV *Ch. Querco-Fagetea*																												
Rubus hirtus		+.2	.	+	+	+	+	+	+	+	+	+	.	+	.	.	.	+	.	+	.	.	.	+	.	V	II	III
Melica nutans		+	+	+	+	1.2	1.1	+.2	.	1.2	.	1.2	1.1	.	+	1.2	.	+	.	+.2	1.2	.	1.2	+.2	.	IV	IV	IV
Poa nemoralis		2.1	3.2	+	+	2.1	1.2	+.2	.	+	.	1.2	2.3	2.2	+	1.2	+.2	+.2	.	+.2	+	1.1	.	+.2	1.2	IV	V	V
Carex digitata		.	+	+	+	.	+	.	.	+.2	.	.	.	.	+	.	.	.	.	.	.	+.2	+	.	.	III	I	II
Melitis melissophyllum		+	.	+	.	+	+	.	.	+	.	+	+.2	.	.	1.1	.	.	.	.	.	.	.	.	.	III	II	II
Polygonatum odoratum		+	+	+	+.2	+	+	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	+	.	+	III	II	II

Table 3 (continued)

Successive number	1	2	3	4	5	6	7	8	9	10	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11	12	13	14			
Anemone nemorosa	.	.	.	+	1.1	.	.	.	+	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	II	I	I
Cephalanthera alba	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Hepatica nobilis	+	.	.	.	+	.	.	+	+	.	+.2	+.2	.	.	+	+	.	.	+	.	.	.	.	.	II	III	II
Lathyrus niger	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	II	I	I
Lathyrus vernus	+	+	+	+	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	II	II	II
Viola reichenbachiana	.	.	.	.	.	+	+	.	.	+	1.1	.	.	.	+	+	+.2	.	+	.	.	1.1	.	.	II	III	III
Galium odoratum	.	.	.	.	.	1.1	.	.	1.1	.	.	.	1.1	.	.	.	+.2	+.2	+.2	1.2	.	2.2	+.2	.	I	III	III
Lamiastrum galeobdolon	.	.	.	.	.	1.1	.	.	+	.	+	.	.	.	+.2	.	.	+	.	.	.	.	.	.	I	II	II
Festuca gigantea	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	+.2	.	+	-	I	II
V Others																											
Anthyrium filix-femina	+	+	+	.	+	1.1	+	+	1.1	+	+	+	+.2	.	+	2.1	+	.	1.2	+	+	+	.	.	V	IV	IV
Hieracium murorum	+	1.1	+	+	1.1	1.1	2.1	1.1	1.1	1.1	1.1	1.2	1.1	+	1.1	+	2.1	.	+	+	+	+	.	+	V	V	V
Dryopteris filix-mas	.	.	+	.	+	+	+	+	+	+	.	.	+	.	+	+	.	+	+	+.2	.	.	.	.	IV	III	III
Oxalis acetosella	.	.	+	.	+	2.2	1.2	1.1	2.2	1.1	1.1	+.2	1.1	.	2.2	1.1	1.2	2.1	1.2	1.1	.	.	+	.	IV	V	IV
Viola riviniana	+	+	+	1.1	+	1.1	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	IV	I	I
Ajuga reptans	+	.	.	.	+	+	.	+	+	+	.	.	.	.	.	+	+	.	+.2	.	.	.	.	.	III	II	II
Convallaria majalis	2.3	1.2	3.2	2.2	1.2	.	.	.	.	+	2.3	2.3	.	2.2	1.2	.	.	.	.	.	.	.	.	+	III	II	II
Cruciata glabra	+	.	+	+	+	+	.	.	1.1	.	1.1	+.2	.	.	1.1	+	.	.	+	+	.	.	.	.	III	III	III
Luzula pilosa	.	.	.	.	+	+	+.2	+	1.1	1.2	.	.	+	+	.	+	+	+	+	+.2	1.1	+.2	1.1	.	III	IV	IV
Monotropa hypopitys	.	+	+	+.2	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
Mycelis muralis	.	.	+	.	+	1.1	+	.	+	.	1.1	+	1.1	.	1.1	.	+.2	.	+	+	.	1.1	.	+	III	IV	IV
Dryopteris carthusiana	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	+	+	+	+	.	.	.	+	+	II	II	III
Festuca rubra	+.2	.	.	.	.	.	+°	+°	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Hypericum maculatum	.	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Valeriana tripteris	.	+.2	+	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Deschampsia cespitosa	.	.	.	.	.	.	.	.	+.2	.	.	.	+	.	.	.	+	.	.	.	.	+	+.2	+.2	I	I	II
Galeopsis pubescens	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	+	.	.	+	.	.	I	II	II
Senecio fuchsii	.	.	+	.	.	.	.	.	.	+	.	.	+	.	+	.	.	.	+	+	.	.	+	+	I	III	III
Impatiens parviflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	2.2	.	.	.	.	-	II	II
Bryophytes d																											
III *Dicranella heteromalla*	2.3	2.2	1.1	+	3.2	2.2	1.2	+.2	+	+.2	1.1	1.1	1.1	+	1.1	+.2	.	+	+	.	+.2	+	.	1.1	V	IV	IV
I *Polytrichum formosum*	1.2	2.2	2.2	2.3	2.2	2.2	1.2	2.2	2.2	+.2	.	.	.	+	.	.	.	+	.	+.2	1.1	.	+	.	V	II	II
III *Pohlia nutans*	2.2	2.2	+	1.1	+	1.2	1.2	+.2	.	+.2	+	+.2	.	+	.	.	+	.	.	.	1.1	+	.	.	V	II	III
IV *Atrichum undulatum*	.	.	+	+	+	+	+	+.2	.	+.2	1.1	.	1.2	+	+.2	+.2	+	+	+.2	.	.	.	.	+.2	IV	IV	IV
V *Brachytecium velutinum*	.	+.2	+	.	.	+	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	III	I	I
V *Calypogea* sp.	.	.	.	.	.	.	+.2	+.2	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Cladonia* sp.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Plagiothecium denticulatum*	1.2	.	+	+	.	.	.	+	.	.	+	+	+.2	+	.	.	.	.	.	.	+.2	+	.	.	II	II	III
Number of species in the table	37	36	46	42	48	45	36	34	50	37	38	31	30	32	34	25	29	25	38	27	21	29	22	33			
Total number of species	43	41	50	55	61	51	44	37	61	40	43	33	34	36	38	26	30	28	42	27	23	33	22	34			

Table 3 (continued)

Sporadic species

II *Lycopodium annotinum* 9 (1.3), *Pyrola chlorantha* 4, *Polygonatum verticillatum* 7 (+.2).

III *Pteridium aquilinum* 4.

IV *Cornus sanguinea* 2c, 6c, 1'b, *Crataegus monogyna* 5c, 5'b, c, *Evonymus europaeus* 5c, *Prunus avium* 10c, *Ribes alpinum* 1b, 2'b, 3' b, *Tilia cordata* 10c, 9'c, 14c, *Ulmus glabra* 3'c, 12b (+.2), *Actaea spicata* 6, 2', 5', *Asarum europaeum* 9, 7' (+.2), 8', *Campanula persicifolia* 1, 1', *C. trachelium* 6, *Carex montana* 5, *C. pilosa* 8 (1.1), *C. sylvatica* 5, 5' (+.2), *Epilobium montanum* 9, 9', *Equisetum sylvaticum* 9', *Galium schultesii* 4 (+.2), *Laserpitium latifolium* 4, 4', *Melampyrum nemorosum* 4, *Milium effusum* 3', *Pulmonaria obscura* 5, 6, 5' (+.2), *Scrophularia nodosa* 9, *Vincetoxicum hirundinaria* 1', *Viola hirta* 3.

V *Betula pubescens* 7c, *Crataegus calycina* 3c, *Juniperus communis* 4c, *Pyrus communis* 1c, 4c, 1'c, *Rosa* sp. 8c, *Rubus wimmerianus* 9 c, *Salix caprea* 7b, 9b, c, *Sambucus racemosa* 6'c, 12c, *Viscum album* ssp. *abietis* 8'a, *Agrostis tenuis* 7, 9, *Astragalus glycyphyllos* 6 (+.2), *Calamagrostis arundinacea* 4 (1.2), 4' (1.2), *C. epigeios* 7, 12 (1.2), *Calluna vulgaris* 4, 11, *Campanula rotundifolia* 4, 9, 4', *Carex pilulifera* 7, 10, *Cephalanthera longifolia* 5, *Digitalis grandiflora* 4, *Epilobium angustifolium* 9', *Euphorbia cyparissias* 2, *Festuca ovina* 4, 3', 4', *Fragaria vesca* 1, 6, *Genista tinctoria* 3, 4, *Hypericum perforatum* 3, 5, *Luzula multiflora* 7, *L. pallescens* 12, *Lycopodium clavatum* 9 (+.2), *Lysymachia vulgaris* 1 (+.2), *Pimpinella major* 2, Sedum *telephium* 2, *Senecio nemorensis* 1', *Taraxacum officinale* 5, *Veronica chamedrys* 9, *Viola collina* 2, 5, *Callicladium haldanianum* 4, *Diphyscium foliosum* 4 (1.2), 5 (+.2), *Fissidens bryoides* 5, *F. taxifolius* 7, *Isopterygium elegans* 1, *Lepidozia reptans* 8 (+.2), *Mnium spinulosum* 9, *Plagiomnium affine* 9, *Plagiothecium curvifolium* 5, 7, *P. laetum* 5, 8.

c) **Ground layer.** An evident retreat of acidophilous forest species (of the *Vaccinio-Piceetea* class) was noticed. The most significant was the decrease of the share of *Vaccinium myrtillus* (Table 6). Thirty years ago the blueberry dominated in most of the *Pino-Quercetum* stands in the ONP, clearly distinguishing them from all other forest communities, dominated by the herbaceous plants in the field layer. A reduction of abundance was also noticed for *Luzula luzuloides* (mainly in the *Abies* and *Pinus* variants) and for *Maianthemum bifolium*, as well as for the carpet mosses *Polytrichum formosum* and *Pleurozium schreberi* (formerly common in the *Abies* and *Pinus* variants, at present nearly completely absent). Those acidophilous forest species (of the *Vaccino-Piceetea* class) which occurred formerly with low abundance or also low presence degrees become quite sporadic (*Hieracium sabaudum*, *H. vulgatum*, *Melampyrum pratense*, *Orthilia secunda*, *Veronica officinalis*) or even were not found at all (*Hieracium laevigatum*, *Lycopodium annotinum*). On the other hand, a group of species of deciduous forest (of the *Querco-Fagetea* class), which formerly occurred only in small quantities in the *Pino-Quercetum*, become more abundant, as *Rubus hirtus* presently dominant in some stands of *Abies* and *Pinus* variants. Several species very scarce or not recorded thirty years ago were now discovered in various study plots e.g. *Festuca gigantea*, *Galium odoratum*, *Impatiens noli-tangere*, *Lamiastrum galeobdolon*, *Melica nutans*, *Milium effusum* and *Moehringia trinervia.*

Table 4. *Pino-Quercetum luzuletosum, Abies alba* variant.

Years of records		1958-1959											1987-1988																
Successive number		1	2	3	4	5	6	7	8	9	10	11	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12	13	14	15			
Altitude (m)		430	435	412	412	409	414	412	398	414	418	412	430	435	412	412	409	414	412	398	414	418	412	412	398	411	395			
Exposure		NW	NW	N	NW	NW	NW	N	SWS	W	NW	NW	NW	NW	N	NW	NW	NW	N	SWS	W	NW	NW	SW	SE	NWN	NW			
Slope degree (°)		5	5	3	5	5	1	3	5	5	10	15	5	5	3	5	5	1	3	5	5	10	15	15	7	15	10			
Mean height of trees (m)		25	28	25	18	23	20	20	22	25	26	28	30	30	28	20	28	24	9	26	25	12	30	25	25	26	24	Presence		
Canopy cover (%)	a1	70	60	50	70	85	70	70	80	45	70	70	40	30	60	80	60	50	70	60	70	30	40	60	70	50	60	degree		
	a2	.	.	.	.	10	.	.	.	55	.	.	70	40	15	15	.	.	.	10	30	30	20	10	.	40	5	in records		
Undergrowth cover (%)		40	60	25	30	15	15	30	5	15	40	10	40	80	70	50	70	60	30	40	15	45	60	15	70	60	50			
Ground layer cover (%)		80	60	80	70	70	80	70	50	65	65	65	15	25	90	80	75	90	60	95	60	90	15	75	60	50	75	1	1'	1'
Bryophytes cover (%)		30	70	30	80	50	30	80	3	20	30	20	10	2	30	2	45	20	1	2	1	1	1	10	60	2	25			
Area of sample plot (m^2)		300	500	400	500	350	500	600	400	250	400	400	300	400	400	500	350	500	600	400	250	200	400	400	400	400	400	11	11'	15
Trees																														
V *Abies alba*	a1	4.3	3.3	3.3	4.4	4.4	4.4	4.3	4.4	+	4.2	4.4	3.3°	2.2°	4.2°	3.3°	4.3°	3.3°	.	3.3°	1.1°	2.2°	2.1°	4.3°	4.3°	3.3	3.3°			
	a2	.	.	.	.	1.1	.	.	.	4.3	.	.	4.3°	.	.	.	.	.	.	1.1°	1.1°	+	.	.	.	1.1	+			
	b	3.2	4.3	2.2	2.2	2.1	2.2	2.2	1.1	2.2	2.2	2.2	3.3°	4.3°	+	2.1	2.2	3.2	2.2°	.	1.1°	1.2°	.	+	+	2.2	1.1	V	V	V
	c	3.2	2.1	1.1	1.1	1.1	2.1	2.2	1.1	1.1	2.1	.	+	+	1.1	1.1	.	+	+	+	+	+	+	2.1	2.1	1.1	+			
V *Betula pendula*	a1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	1.2	.	.	.			
	b	1.1	+	+	+	+	+	1.1	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	V	I	I
	c	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
V *Fagus sylvatica*	a1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	1.1	.	+	.	.	.	1.1	.	.	.	.	.			
	a2	.	.	.	.	+	.	.	.	.	.	.	2.2	3.3	1.1	.	.	.	.	+	2.2	2.2	+	1.1	.	2.3	.			
	b	2.1	2.1	1.1	.	.	+	.	.	.	+	+	+	+	.	.	+	.	+	.	.	.	3.3	.	.	1.1	.	V	V	V
	c	+	+	+	+	+	.	.	+	+	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	+			
V *Pinus sylvestris*	a1	.	2.1	3.1	+	1.1	1.1	1.1	.	3.3	3.3	2.2	.	+°	2.1	1.1	+	+	.	.	3.2	1.1	1.1	.	1.2°	2.2	1.2	V	IV	IV
	c	+	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
I *Populus tremula*	a2	.	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1.1	.	+	.	.	.			
	b	+	+	1.1	1.1	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	1.2	.	+	.	.	.	V	I	I
	c	.	.	+	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	2.2	.	+	.	.	.			
III *Sorbus aucuparia*	a2	.	.	.	+	.	.	.	.	.	.	.	+	.	.	2.1	.	.	.	.	+.2	.	+	.	.	.	.			
	b	1.1	1.1	+	+	+	1.1	1.1	1.1	+	3.2	2.1	.	+	2.1	.	2.1	2.1	1.1	1.1	.	1.1	+	.	+	1.1	+	V	V	V
	c	.	.	+	+	+	.	.	.	1.1	1.1	1.1	+	+	+	.	+	1.1	+	+	+	1.1	+	1.1	+	+	.			
III *Picea abies*	a1	+	.	.	+	.	+	.	.	+	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+			
	b	.	.	.	+	+°	.	.	.	.	1.1	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	IV	II	II
	c	.	.	.	+	+	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.			
V *Quercus petraea*	a1	.	.	2.1	.	.	1.1	.	.	.	.	+	.	.	+.2	2.2	1.1	2.2	4.4	.	.	.	.	.	1.1	.	.			
	a2	.	.	.	1.1	1.1	.	.	.	.	.	.	.	.	.	2.1	.	.	.	.	+	.	.	.	.	.	.	IV	IV	III
	b	.	.	.	1.1	+	.	2.1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+			
	c	.	.	1.1	1.1	+	1.1	.	.	.	+	1.1	.	.	+	+	.	+	+	.	+	+	.	.	.	+	.			
IV *Acer pseudoplatanus*	b	+	+	.	.	.	.	.	+	+	.	.	.	+	.	+	.	.	1.1	1.2	.	.	.	.	.	.	2.2	III	IV	IV
	c	.	.	.	.	.	.	.	+	.	+	.	+	1.1	.	.	.	.	+	+	+	.	+	+	.	+	+			
V *Betula pubescens*	b	.	.	+	.	.	+	.	.	+	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
	c	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			

Table 4 (continued)

Successive number		1	2	3	4	5	6	7	8	9	10	11	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12	13	14	15			
IV *Acer platanoides*	b	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	I
	c	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.			
IV *Carpinus betulus*	b	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	II	II	II
	c	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+			
V *Malus sylvestris*	b	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
	c	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
V *Quercus robur*	a1	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	+	.	.	.	II	III	III
	b	.	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.			
	c	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.			
V *Larix decidua*	a1	.	.	.	.	.	.	.	3.2	.	.	.	.	.	.	.	.	.	.	3.2	.	.	.	1.1	.	.	1.2	I	I	II
	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.			
Shrubs																														
V *Frangula alnus*	b	+	+	1.1	1.1	.	+	+	+	+	.	+	.	.	1.2	1.1	1.1	1.1	+	+	.	.	.	+	.	.	1.1	V	IV	IV
	c	.	+	.	+	+	+	.	+	+	.	+	.	.	.	+	+	.	+	.	+	+	.	.	.	.	.			
V *Rubus idaeus*	b	+	+	.	.	.	.	.	.	.	1.1	.	.	.	1.2	+	+	+.2	.	.	.	.	.	.	.	.	.	V	V	V
	c	.	.	+	.	+	+	+	.	+	.	+	.	+	1.1	2.2	2.3	3.3	+	2.2	+.2	1.1	+	+	2.1	+	+			
V *Salix caprea*	b	+	.	.	+	.	+	+	.	.	+	.	.	.	.	.	.	.	1.1	.	.	+	.	.	.	.	.	IV	II	I
	c	+	.	+	+	+	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	1.1	.	.	.	.	.			
IV *Corylus avellana*	b	.	.	.	.	.	.	.	+	1.1	.	+	.	.	.	.	.	.	.	1.2	+.2	.	.	1.1	+	2.2	1.2	II	II	III
	c	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.			
V *Rubus nessensis*	b	.	.	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	I
	c	.	1.1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.			
V *Sambucus racemosa*	b	.	.	+°	.	.	.	.	.	.	+	+	+	.	2.2	+	3.3	3.3	.	3.3	2.2	2.2	.	+	2.2	2.2	3.3	II	V	V
	c	.	.	.	.	.	.	.	.	.	.	.	1.1	+.2	.	.	.	.	.	.	2.2	2.2	.	+	.	+	1.1			
V *Rubus suberectus*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	I	II	II
	c	.	.	+	.	.	+	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.			
IV *Ribes uva-crispa*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	-	II	I
	c	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	+	.	.	.	.	.			
V *Sambucus nigra*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	3.2	2.1	1.1	.	.	.	.	2.2	1.1	.	4.2	.	.	-	III	III
	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	+	+	.	.	.			
Ground layer																														
I ***Ch. Pino-Quercetum*** (ˣloc.), ***Pino-Quercion***																														
ˣ*Luzula luzuloides*		+	1.2	2.2	2.2	1.1	2.3	+.2	2.2	2.2	2.2	2.2	+	.	.	+	+	.	.	+	.	1.2	.	2.2	+	+.2	.	V	III	III
Veronica officinalis		+	.	+	+	+	+	+.2	+	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	V	I	I
ˣ*Hieracium vulgatum*		+	+	+	+	+	+	.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	IV	I	I
ˣ*Hieracium sabaudum*		.	.	.	+	+	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
ˣ*Hieracium laevigatum*		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	-	-
II ***Ch. Vaccinio-Piceetalia***																														
Orthilia secunda		+	+	+	+.2	1.1	+.2	.	1.2	+	+.2	+.2	.	.	.	.	.	.	.	.	.	.	+	+.2	.	+.2	.	V	I	I
Trientalis europaea		1.1	1.1	1.1	1.1	1.1	1.1	1.1	+	+	1.1	+.2	.	+	1.2	+.2	2.2	2.2	1.1	.	+.2	1.1	+.2	.	1.2	1.2	1.1	V	V	IV
Vaccinium myrtillus		4.3	3.2	4.5	4.3	4.4	3.3	4.4	3.4	4.3	4.3	4.3	+°	1.2	1.2	2.2	2.2	1.1	1.2	+°	2.1	1.2	+.2	3.3	2.2	1.1	+.2	V	V	V
Lycopodium annotinum		1.2	+.3	.	.	+.2	.	.	.	.	1.2	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-

Table 4 (continued)

Successive number	1	2	3	4	5	6	7	8	9	10	11	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12	13	14	15			
Melapyrum pratense	.	.	1.1	1.1	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Polygonatum verticillatum	.	.	+.2	.	+.2	.	.	+.2	.	.	+	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+.2	II	I	II
III ***Ch. Vaccinio-Piceetea***																													
Maianthemum bifolium	3.2	2.2	2.2	3.3	3.3	3.3	2.2	3.3	1.1	3.3	3.2	+	+	2.2	1.2	2.1	2.2	2.1	+	2.1	1.1	+	3.3	2.2	2.2	+	V	V	V
Calamagrostis arundinacea	+.2	.	.	.	.	.	.	1.2	1.1	.	+.2	.	.	.	.	.	.	.	3.3	.	.	+	+.2	.	.	+.2	II	I	II
Pteridium aquilinum	.	.	2.1	.	+	.	.	+	.	1.2	.	.	.	.	.	.	1.2	.	1.1	.	.	.	.	1.2	.	.	II	I	I
Solidago virgaurea	.	.	.	.	.	+	.	+	+	.	+	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	II	I	I
Dryopteris dilatata	+	+	.	.	.	.	.	.	.	.	.	+	+	+.2	+	2.2	+.2	.	.	.	.	.	.	1.1	.	+	I	III	III
IV ***Ch. Querco-Fagetea***																													
Rubus hirtus	1.1	+	.	.	+	.	+°	+	+	.	.	+	.	+	1.2	.	+	2.2	2.2	2.2	3.3	+	.	+	+.2	3.3	III	V	IV
Poa nemoralis	+.2	.	.	.	.	+.2	+.2°	.	+	.	.	.	.	+.2	.	+	.	+.2	.	.	+	.	+	+	.	+	II	II	III-
Anemone nemorosa	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	+	.	.	.	.	.	.	I	II	II
Festuca gigantea	+	.	.	.	.	.	.	.	.	.	.	.	.	1.2	+	+	+.2	+	.	+	+.2	.	.	1.1	.	+	I	IV	III
Lamiastrum galeobdolon	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	2.3	.	+	.	.	1.2	.	.	.	.	.	I	II	II
Melica nutans	.	+.2	.	.	.	.	.	+	.	.	.	.	.	+	+.2	+.2	.	+.2	.	+.2	+	+	1.2	+.2	.	.	I	IV	III
Milium effusum	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	+	+	.	.	.	.	.	+	1.1	I	III	III
Polygonatum multiflorum	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+.2	.	.	+	+.2	I	II	II
Viola reichenbachiana	.	.	.	.	.	.	.	+	.	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	I	II	I
Impatiens noli-tangere	.	.	.	.	.	.	.	.	.	.	.	.	.	3.3	2.2	+.2	+	.	+	.	.	.	.	3.2	.	.	-	II	II
Moehringia trinervia	.	.	.	.	.	.	.	.	.	.	.	+	.	+.2	+	+	+	.	+	.	.	.	.	+	.	1.1	-	III	III
V Others																													
Anthyrium filix-femina	+	1.1	+	+	1.1	+	+°	1.1	+	1.1	+	1.1	1.1	2.2	2.1	2.2	2.1	2.1	+	2.2	3.3	1.1	1.1	1.1	1.2	2.2	V	V	V
Dryopteris carthusiana	1.1	+	+	+	1.1	+	1.1	+	+	+	.	1.1	+	1.1	1.2	1.2	1.1	1.2	+	+	.	.	+	2.2	2.2	+	V	V	V
Hieracium murorum	1.1	+	+	+	+	1.1	.	1.1	1.1	+	1.1	.	.	.	.	.	.	.	.	1.1	+	.	.	+	.	.	V	I	I
Luzula pilosa	1.1	2.2	+	1.1	1.1	2.1	2.2	1.2	+	1.1	1.1	+	+	1.1	+	+	+	+	+	+	+.2	+	1.1	+	+	.	V	V	V
Oxalis acetosella	1.1	1.2	+.2	.	2.2	2.2	1.2	2.2	1.1	1.1	+	1.2	2.2	2.2	2.1	2.2	1.1	+.2	1.2	1.2	1.2	+	.	2.2	1.2	1.1	V	V	V
Agrostis tenuis	.	+.2°	.	.	1.1	+	.	.	+	+°	+°	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	-	-
Festuca rubra	.	+°	+.2°	+°	3.2	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	-	-
Dryopteris filix-mas	+	+	.	.	+	+	.	.	+	.	.	.	.	.	+	+	+.2	.	.	.	1.2	.	.	+.2	1.2	.	III	II	II
Epilobium angustifolium	+	+	.	.	.	+°	+	+	.	+	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	III	II	I
Hypericum maculatum	+	+°	.	+°	+	+°	.	.	.	.	+°	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
Carex pilulifera	.	+.2°	+°	.	+°	.	.	.	.	.	+°	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	II	I	I
Hypericum perforatum	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	II	I	I
Mycelis muralis	+	+	.	.	.	.	.	+	.	.	+	.	.	+	.	.	+	.	+	+	.	.	+.2	.	.	.	II	II	II
Viola riviniana	.	.	.	.	.	+	.	.	+	+	+	.	.	.	+	.	+	.	.	+	.	.	+	.	+	.	II	II	II
Ajuga reptans	+	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	I	II	I
Convallaria majalis	.	.	.	.	.	.	.	.+.2	3.2	.	.	.	.	.	.	.	.	.	.	2.3	.	+	1.2	.	.	+.2	I	I	II
Deschampsia cespitosa	+	.	.	.	.	.	.	.	.	.	+	+°	.	.	.	+.2	1.2	1.2	.	+	.	.	.	.	.	1.2	I	III	II
Galeopsis pubescens	.	.	.	.	.	.	.	.	.	.+	.	+	.	+	.	.	.	.	+.2	.	.	.	.	.	.	+	I	II	II
Senecio fuchsii	+	+	.	.	.	.	.	.	.	.	.	1.1	2.2	4.4	+	2.1	3.3	.	3.3	.	.	1.1	2.1	1.2	1.2	3.3	I	IV	IV
Festuca ovina	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	+	.	.	.	-	II	II
Galeopsis speciosa	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1.1	.	.	.	+	.	.	.	.	.	-	III	II

Table 4 (continued)

Successive number	1	2	3	4	5	6	7	8	9	10	11	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12	13	14	15			
Gymnocarpium dryopteris	.	.	.	.	.	.	.	.	.	.	.	+.2	+	.	.	.	+.2	.	+	+	.	+.2	.	+	1.2	.	-	III	III
Impatiens parviflora	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.2	3.3	2.1	2.2	+	2.1	.	.	.	.	.	+	.	-	IV	III
Senecio nemorensis	.	.	.	.	.	.	.	.	.	.	.	.	+	1.1	.	1.1	+	.	.	+	.	.	+	.	.	.	-	III	II
Urtica dioica	.	.	.	.	.	.	.	.	.	.	.	+.2	.	+	+	+	.	+	+	.	+	.	.	.	+	.	-	IV	III
Bryophytes d																													
I *Polytrichum formosum*	3.2	4.4	1.2	2.3	2.2	2.3	4.4	1.2	2.2	2.2	2.2	.	+	1.2	.	1.2	1.2	+.2	+.2	+	.	+	+.2	2.3	+.2	+.2	V	IV	IV
III *Pleurozium schreberi*	2.2	2.2	2.4	4.5	3.2	2.3	3.3	.	2.2	1.2	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	-	-
III *Dicranella heteromalla*	.	.	+.2	+.2	.	+	.	+	+	+.2	1.2	+	+	.	.	1.2	+	.	.	.	+.2	.	1.2	.	.	+.2	IV	III	III
III *Plagiothecium curvifolium*	2.2	2.2	.	+.2	1.2	+.2	2.2	.	.	+	.	.	.	.	+.2	1.2	.	.	.	.	.	.	.	.	.	.	IV	I	I
III *Pohlia nutans*	1.1	1.2	+.2	+.2	+	1.2	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+.2	.	+.2	.	.	+	IV	I	II
IV *Atrichum undulatum*	.	+	.	.	.	+	.	.	.	.	+.2	1.2	.	.	+.2	+.2	+.2	.	.	.	.	.	.	.	.	+.2	II	II	II
V *Calypogeia* sp.	.	.	+.2	.	.	+.2	.	.	.	+	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Plagomnium affine*	2.2	2.2	.	.	.	+.2	.	+.2	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Plagomnium rostratum*	.	.	.	.	.	.	.	.	.	.	.	.	.	2.3	1.2	3.3	2.2	.	+.2	.	.	+	.	3.3	+.2	2.3	-	III	III
Number of species in the table	46	40	36	33	41	44	27	36	40	39	41	26	28	34	40	42	40	36	30	32	34	24	35	34	33	37			
Total number of species	52	45	42	39	43	48	30	41	46	39	50	31	30	37	44	44	43	38	31	32	35	24	38	36	38	40			

Sporadic species

II *Moneses uniflora* 9 (1.1), 11 (2.2), *Pyrola chlorantha* 9, *P. minor* 6, 11 (+.2), 3', *Sphagnum girgensohnii* 2 (1.2), 7 (1.3).

III *Deschampsia flexuosa* 3 (+.2), 14, *Thelypteris limbosperma* 4, *Leucobryum glaucum* 4 (+.2).

IV *Crataegus monogyna* 4'b, *Lonicera xylosteum* 9c, *Prunus avium* 12c, *Tilia cordata* 9b, 14c, *Viburnum opulus* 8c, 9c, *Asarum europaeum* 9, *Carex digitata* 13, *C. pilosa* 8 (1.1°), 14 (+.2), 15, *C. sylvatica* 11 (+.2), 1', 6', *Epilobium montanum* 2, *Equisetum sylvaticum* 1, 1', 13 (+.2), *Galium odoratum* 1 (+.2), 2', 4', *G. schultesii* 11, *Mercurialis perennis* 9' (+.2), *Paris quadrifolia* 4', 9', *Scrophularia nodosa* 8, *Vinca minor* 3 (+.3), 3' (+.2).

V *Alnus glutinosa* 7b, 7'a, *Juniperus communis* 4b, 6b, *Larix decidua* subsp. *polonica* 11a, *Pyrus communis* 4'c, 5'c, *Quercus rubra* 1b, 2b (1.1), 1'a, *Salix* cfr. *aurita* 7b, c, *Salix* sp. 11b, *Sambucus* sp. 8c, *Anthoxanthum odoratum* 1, *Calamagrostis epigeios* 5' (+.2), 15 (+.2), *Calluna vulgaris* 9, *Campanula rotundifolia* 12 (+.2), *Carex bryzoides* 6', 7', *Cruciata glabra* 3, 6, 12, *Danthonia decumbens* 3, *Fragaria vesca* 8, *Galeopsis* sp. 2, *Luzula multiflora* 11, *Lycopodium clavatum* 2, *Lysymachia vulgaris* 1, 1' (1.1), *Monotropa hypopitys* 4, *Rubus corylifolius* 8' (1.1), *Rubus* sp. 5, 11, *Stellaria media* 3', *Thelypteris phegopteris* 1 (+.2), 15, *Tussilago farfara* 10', *Valeriana tripteris* 11 (+.2), *Brachythecium curtum* 3, *B. velutinum* 3, 5, *Mnium* sp. 4 (+.2), *Plagiothecium denticulatum* 1' (1.1), 6', *P. laetum* 2', 13 (1.2).

Table 5. *Pino-Quercetum luzuletosum, Pinus sylvestris* variant.

Years of records		1958-1959								1987-1988												Presence degree in records		
Successive number		1	2	3	4	5	6	7	8	1'	2'	3'	4'	5'	6'	7'	8'	9	10	11				
Altitude (m)		410	392	400	392	441	431	430	429	410	392	400	392	441	431	430	429	424	424	445				
Exposure		NW	SWS	NW	NEN	E	SW	NE	NEN	NW	SWS	NW	NEN	E	SW	NE	NEN	NE	NWN	E				
Slope degree (°)		5	15	2	10	5	10	5	10	5	15	2	10	5	10	5	10	5	3	5				
Mean height of trees (m)		20	20	25	26	14	24	14	16	22	22	26	26	18	25	22	20	18	22	20				
Canopy cover (%)	a1	70	70	65	30	65	65	85	70	30	40	35	40	50	55	60	70	75	60	40				
	a2	20	.	.	50	.	.	.	.	60	50	60	80	70	65	20	30	.	.	50				
Undergrowth cover (%)	b	60	60	60	40	30	60	30	30	40	50	15	5	20	15	25	15	50	40	40				
Ground layer cover (%)	c	80	70	60	70	80	75	65	65	65	75	55	5	15	50	70	70	85	60	50		1	1'	1'
Bryophytes cover (%)	d	50	20	70	60	40	25	10	10	.	5	2	2	.	5	5	.	.	2	20				
Area of sample plot (m^2)		300	400	400	300	500	100	300	500	300	400	400	300	400	100	300	100	300	250	250		8	8'	11
Trees																								
V *Abies alba*	a	+	2,1	1.1	+	.	.	+	+	+°	1.1°	+	.	2.2	.	.	.	.	+	1.2				
	b	2.2°	2.2	3.2	+	2.1	3.2	3.2	2.2	2.2°	.	2.1°	.	1.1	+	1.1°	+°	.	3.3°	2.2		V	V	V
	c	+	1.1	1.1	.	1.1	.	+	+	1.1	1.1°	+	.	.	.	+	.	+	2.1	.				
V *Fagus sylvatica*	a1	.	.	.	.	.	.	1.1	1.1	.	.	+	.	.	.	3.2	.	.	.	.				
	a2	+	.	.	.	.	.	.	.	1.2	1.2	3.3	4.3	4.4	3.3	1.1	2.2	+	+	+				
	b	.	2.2	.	.	+	1.1	+	+	1.1	1.1	.	+	1.1	.	1.1	2.1	+	1.1	.		V	V	V
	c	.	+	+	+	+	+	1.1	+	.	.	.	.	.	.	.	+	.	+	+				
V *Pinus sylvestris*	a	4.3	4.3	4.3	4.2	4.3	4.3	2.2	2.1	2.2°	2.2°	2.2	3.3	3.3	3.3	+°	2.2	4.3°	3.3	3.3				
	b	.	+	.	2.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.		V	V	V
	c	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.				
V *Quercus petraea*	a	1.1	+	.	.	.	.	3.2	2.1	3.3	3.2	+	.	.	.	2.1	.	.	3.3	.				
	b	1.1	2.1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.		V	III	III
	c	2.1	1.1	.	.	+	+	.	+	+	1.1	.	+	.	.	+	.	.	1.1	.				
V *Betula pendula*	b	+	1.1	+	+	2.1	1.1	.	.	.	.	.	.	+	.	.	.	.	.	.		IV	I	I
	c	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.				
III *Picea abies*	a	.	.	+	2.2	.	1.1	+	1.1	.	.	.	1.1	.	+	+°	+	.	.	+				
	b	.	.	+	.	+	2.2	.	+	.	.	+°	+°	.	1.1	.	.	.	.	.		IV	IV	IV
	c	.	.	+	.	.	.	+	.	.	.	.	.	.	.	+	+	+	.	.				
I *Populus tremula*	a	2.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	+	.				
	b	1.1	1.1	+	+	1.1	+	.	.	.	.	.	.	+	.	.	.	2.1	.	.		IV	II	III
	c	.	.	.	+	.	.	.	.	.	+	+	.	+	.	.	.	+	.	.				
V *Quercus robur*	a	+	.	.	.	.	.	+	2.1	1.1	.	.	.	.	.	.	+	+	.	.				
	b	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.		IV	II	II
	c	.	.	.	+	+	+	+	+	.	.	.	.	+	.	.	.	+	.	.				
IV *Acer pseudoplatanus*	b	.	.	+	.	.	.	+	.	.	.	.	.	+	+	.	.	+	.	+		III	IV	IV
	c	.	.	.	.	+	+	+	.	.	+	+	+	+	+	.	.	.	+	.				
IV *Carpinus betulus*	b	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.		II	I	I
	c	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	.	.				
V *Larix decidua*	a	.	.	.	.	.	.	1.1	3.3	.	.	.	.	.	.	2.2°	3.3	.	.	.		II	II	I

Table 5 (continued)

Successive number		1	2	3	4	5	6	7	8	1'	2'	3'	4'	5'	6'	7'	8'	9	10	11			
IV *Acer platanoides*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I	II	II
	c	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.			
IV *Prunus avium*	b	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	I	I	II
	c	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.			
IV *Fraxinus excelsior*	b	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	-	II	II
	c	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+			
Shrubs																							
III *Sorbus aucuparia*	b	+	1.1	2.2	2.1	1.1	1.1	.	+	1.1	2.2	+	.	+	+	+	.	2.2	1.1	2.2	V	V	V
	c	+	+	.	.	1.1	+	+	1.1	+	2.2	+	+	+	+	.	.	.	+	.			
IV *Corylus avellana*	b	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	IV	II	I
	c	.	+	.	.	.	+	+	+	.	+	+	.	.	.	.	.	.	.	.			
V *Frangula alnus*	b	+	+	.	1.1	.	.	+	1.1	.	+	.	+	.	+	+	.	1.1	+	+	IV	IV	IV
	c	+	+	.	+	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.			
V *Rubus idaeus*	b	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV	IV	III
	c	+	.	.	.	+	+	+	.	1.2	+	+	.	+.2	1.1	.	.	+	.	.			
V *Salix caprea*	b	+	+	1.1	.	+	.	.	.	.	.	.	.	+	.	.	.	1.1	.	1.2	IV	I	II
	c	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
V *Rubus wimmerianus*	c	.	+	.	1.2	1.1	+	.	.	.	.	.	.	.	.	.	.	1.1	.	.	III	-	I
V *Betula pubescens*	b	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	I	I
	c	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.			
V *Juniperus communis*	b	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	I	I
	c	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.			
V *Rubus corylifolius*	b	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	I
	c	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	2.1			
V *Rubus nessensis*	b	+	.	+	1.1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	II	-	I
V *Salix aurita x caprea*	b	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Sambucus nigra*	b	.	.	+	.	.	.	.	.	+	.	1.1	.	+.2	.	.	.	1.1	.	.	I	IV	III
	c	.	.	.	.	.	.	.	.	+	+	1.1	.	.	+	.	.	.	.	.			
V *Sambucus racemosa*	b	.	.	.	.	.	.	.	.	3.2	.	+	.	.	.	.	.	.	1.1	2.2	-	IV	IV
	c	.	.	.	.	.	.	.	.	1.1	.	1.1	+	+	.	+	.	.	.	1.1			
Ground layer																							
I *Ch. Pino-Quercetum* (ˣloc.), *Pino-Quercion*																							
ˣ*Luzula luzuloides*		2.2	3.3	1.1	1.1	1.2	3.3	+.2	2.2	.	2.2	+.2	.	.	.	.	.	1.2	1.1	.	V	II	II
Veronica officinalis		+.2	+	+	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	V	-	-
ˣ*Hieracium laevigatum*		+	+.2	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
ˣ*Hieracium sabaudum*		.	+.2	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	+	.	III	-	I
ˣ*Hieracium vulgatum*		.	+	.	.	+	.	.	.	.	.	.	.	+.2	.	.	.	.	+	.	II	I	I
Holcus mollis		.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	I	-	-
II *Ch. Vaccinio-Piceetalia*																							
Orthilia secunda		+	+.2	1.1	1.1	+.2	+.2	.	+	.	1.2	.	.	.	.	.	.	.	.	+.2	V	I	I
Vaccinium myrtillus		5.5	3.4	3.2	4.3	5.4	4.3	4.3	3.3	2.2	3.3°	1.1	+°	1.1	1.1	1.2	1.1	3.2	3.2	2.2	V	V	V

Table 5 (continued)

Successive number	1	2	3	4	5	6	7	8	1'	2'	3'	4'	5'	6'	7'	8'	9	10	11			
Melampyrum pratense	1.1	1.1	+	.	+	.	+	.	.	1.1	.	.	.	.	.	.	.	1.1	.	IV	I	I
Lycopodium annotinum	.	+.2	(+)	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Pyrola minor	.	.	.	.	+	+.2	+	.	.	.	.	(+)	.	.	.	.	(+.2)	.	.	II	I	I
Trientalis europaea	2.2	.	2.2	2.1	.	.	.	.	1.1	.	2.1	.	+.2	+	+	.	1.1	.	+.2	II	IV	IV
III *Ch. Vaccinio-Piceetea*																						
Maianthemum bifolium	2,1	+	3.2	2.1	+	+	2.2	3.2	1.1	1.1	2.3	..	1.1	.	2.1	1.1	1.1	1.2	2.1	V	IV	IV
Pteridum aquilinum	.	+	.	.	.	1.2	1.1	.	.	.	.	.	.	.	2.2	.	2.3	.	.	II	I	I
Solidago virgaurea	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	II	I	I
IV *Ch. Querco-Fagetea*																						
Rubus hirtus	.	+	1.1	1.2	.	1.2	1.1	+	2.2	.	+	+	+.2	2.2	4.3	4.3	3.3	+.2	.	IV	V	V
Anemone nemorosa	+	+.2	.	+	.	.	+	(1.1)	.	.	+	.	+	.	1.1	+	1.1	+	+	IV	III	IV
Equisetum sylvaticum	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	II	I	I
Melica nutans	.	.	.	.	+	.	.	+.2	+	+.2	.	.	+	+	1.1	+	+	.	.	II	IV	IV
Poa nemoralis	.	+	.	.	.	.	1.1	.	.	1.1	.	.	.	.	.	.	+	1.2	+	II	I	II
Scrophularia nodosa	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Viola reichenbachiana	+	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	II	I	I
Festuca gigantea	.	.	+	.	.	.	.	.	+.2	+.2	+	.	.	1.1	+	.	+	.	+	I	IV	IV
Lamiastrum galeobdolon	.	.	.	.	.	.	+	.	3.2	.	+.2	.	.	.	.	.	.	.	.	I	II	I
Galium odoratum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+.2	+.2	-	I	II
Milium effusum	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	-	II	II
V Others																						
Hieracium murorum	+	+	+	+	+	1.1	+	1.1	.	+	.	.	.	+	.	.	.	.	+	V	II	II
Hypericum maculatum	+	.	+	+	+	+	+	+°	.	.	.	.	.	.	.	.	.	.	.	V	-	-
Luzula pilosa	1.2	+	1.1	2.2	1.2	1.1	+	1.2	+	+	.	.	+	+.2	.	+	+	+	+	V	IV	IV
Agrostis tenuis	+	.	1.2	+°	+.2	1.2	+	.	.	.	.	.	.	.	.	.	.	.	.	IV	-	-
Anthyrium filix-femina	.	.	1.1	+	+	1.1	+	2.2	+	.	2.1	1.1	1.1	1.1	2.1	2.1	+	+	1.1	IV	V	V
Dryopteris carthusiana	.	.	+	1.1	+	+	1.1	1.1	+	.	+	+	+.2	+	1.1	+.2	+.2	+	2.1	IV	V	V
Festuca rubra	2.2	.	+.2	2.2	2.2	+.2	.	+°	.	.	.	.	.	.	.	.	.	.	.	IV	-	-
Mycelis muralis	+	+	+	.	.	.	+	+	.	+	.	.	.	.	.	.	.	1.1	+	IV	I	II
Oxalis acetosella	.	.	2.2	1.1	+	.	2.2	1.1	2.1	.	2.2	.	1.1	1.1	2.2	1.2	1.2	2.2	3.3	IV	IV	V
Ajuga reptans	.	.	.	.	+	+.2	+	+	.	.	.	.	.	.	.	.	.	.	+	III	-	I
Calluna vulgaris	+	+°	+	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
Convallaria majalis	.	+.3	.	.	.	+.2	2.3	+.3	.	2.3	.	.	.	.	.	.	.	.	.	III	I	I
Viola riviniana	.	.	.	+	+	.	+	+	.	.	+	.	.	+	.	.	+	+	.	III	II	II
Carex pilulifera	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	II	I	I
Cruciata glabra	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	+	+	+	II	-	II
Dantonia decumbens	1.1	+	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Deschampsia cespitosa	.	.	.	+.2	.	.	+.2	.	.	.	.	.	.	.	+.2	.	1.1	.	.	II	I	I
Dryopteris filix-mas	.	.	.	.	.	+	+	+	+	.	+	.	.	.	+	1.1	+.2	.	.	II	III	III
Epilobium angustifolium	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+.2	.	II	I	I
Festuca ovina	+.2	+°	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	+	+	II	I	II

Table 5 (continued)

Successive number	1	2	3	4	5	6	7	8	1'	2'	3'	4'	5'	6'	7'	8'	9	10	11			
Genista tinctoria	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Gymnocarpium dryopteris	.	.	.	+	.	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Hypericum perforatum	.	+°	.	.	.	+	.	.	.	.	.	.	.	.	+	.	+	+	.	II	I	II
Lycopodium clavatum	.	.	.	.	+	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Potentilla erecta	+.2	.	.	+	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
Galeopsis pubescens	.	+	.	.	.	.	.	.	+.2	.	+	+	+	+	.	.	.	+	.	I	IV	III
Lysimachia vulgaris	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	+	.	+	I	I	II
Senecio fuchsii	.	.	.	.	.	.	.	+	+.2	.	.	.	.	.	.	.	+	3.2	1.2	I	I	II
Impatiens parviflora	.	.	.	.	.	.	.	.	2.1	+	.	.	.	1.1	.	.	2.2	1.1	.	-	II	III
Urtica dioica	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	+.2	.	.	-	II	II
Bryophytes d																						
III *Pleurozium schreberi*	3.3	2.3	3.3	3.3	3.3	2.3	+	1.2	.	.	.	.	.	.	.	.	.	.	+.2	V	-	I
I *Polytrichum formosum*	2.3	1.2	3.3	3.3	2.2	1.2	2.2	2.2	.	.	+	.	.	+.2	.	.	.	.	1.2	V	II	II
V *Plagomnium affine*	.	.	2.2	1.1	+.2	.	+	.	.	.	.	.	.	.	.	.	.	.	.	III	-	-
III *Pohlia nutans*	.	1.2	.	.	+	+	+	.	.	+	.	.	+	.	.	.	.	.	.	III	II	I
V *Calypogea* sp.	+	+.2	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
V *Cladonia* sp.	.	+	.	.	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	II	-	-
III *Dicranella heteromalla*	.	1.2	.	.	.	+	+	.	.	.	.	.	.	+.2	+	.	.	.	+	II	II	II
V *Plagiothecium curvifolium*	+	.	.	.	.	2.2	.	+	.	+.2	.	.	.	.	.	.	.	.	+.2	II	I	I
IV *Atrichum undulatum*	.	.	.	.	.	.	+.2	.	.	+.2	+	+	.	+.2	+	.	.	+.2	+	I	IV	IV
Number of species in the table	39	46	39	38	44	50	51	39	30	33	28	17	26	28	27	18	43	33	30			
Total number of species	41	51	43	42	45	56	55	43	31	39	28	18	26	33	29	18	50	35	40			

Sporadic species

II *Dryopteris dilatata* 1' (1.1), *Monotropa hypopitys* var. *hirsuta* 6 (+.2), *Ptilium crista-castrensis* 4.

III *Calamagrostis arundinacea* 8 (+.3), 2' (+.2), *Deschampsia flexuosa* 7 (+.2), 9, *Leucobryum glaucum* 1 (1.1).

IV *Lonicera xylosteum* 2'b, *Ribes uva-crispa* 6'c (+.2), 9c, *Tilia cordata* 2b,c, 2'b, *Viburnum opulus* 2c, 2'b, *Carex digitata* 8 (+.2), 6' (+.2), *C. pilosa* 7, *Galium schultesii* 9, *Melampyrum nemorosum* 2, 2', *Moehringia trinervia* 7' (+.2), 11 (+.2), *Paris quadrifolia* 6', 11.

V *Alnus glutinosa* 1a,b, *Malus sylvestris* 4b, 9b, *Quercus rubra* 7'a, 11c, *Salix aurita* 4b (1.1), *Sambucus* sp. 8c, *Anthoxanthum odoratum* 4, *Aruncus dioicus* 9, *Calamagrostis epigeios* 11 (+.2), *Calamagrostis* sp. 6, *Campanula rotundifolia* 2, *Carex ovalis* 3, *Epilobium montanum* 10, *Fragaria vesca* 3, 6' (+.2), *Hieracium pilosella* 5, *Luzula multiflora* 6, *Omalotheca sylvatica* 6, *Poa annua* 9 (+.2), *Rubus* sp. 5, 10, *Rumex acetosella* 6, *Thelipteris phegopteris* 7, *Valeriana tripteris* 2, *Veronica chamaedrys* 3,9, *Brachythecium velutinum* 2 (+.2), *Plagiomnium rostratum* 11 (2.2), *Plagiothecium denticulatum* 4', *P. laetum* 7 (1.2), *Polytrichum commune* 3 (2.2), *P. juniperinum* 6 (1.2), *Rhytidiadelphus squarrosus* 4.

The group of accompanying species ("others" in the Tables 3, 4, 5), which include plants of various ecological characters, also contributed to the expanding species. The most noticeable among them are the nitrophilous plants of forest clearings (of the *Epilobietea angustifolii* class): *Senecio fuchsii*, *S. nemorensis* and *Urtica dioica*. *Senecio fuchsii* and *S. nemorensis* grow in abundance mainly in the *Abies* variant, in stands with strongly thinned canopy. The newcomer *Impatiens parviflora* also belongs to the successful colo-

Table 6. Numbers of occurrences (n) and mean percentages of coverage (%) of selected species in three variants of the *Pino-Quercetum* association. Calculations based on the original phytosociological records from 1958-59 and those repeated in 1986-88.
Conversion index from abundance degrees to percentage of coverage:
5 = 87.5%, 4 = 62.5%, 3 = 37.5%, 2 = 15.0%, 1 = 3.0%, + = 0.5%.
Roman numerals indicate the syntaxonomic groups of species (as in Tables 3, 4, 5).

		Fagus sylvatica variant 10 records				*Abies alba* variant 11 records				*Pinus sylvestris* variant 8 records			
		1958-59		1986-88		1958-59		1986-88		1958-59		1986-88	
		n	%	n	%	n	%	n	%	n	%	n	%
Trees and shrubs													
V *Fagus sylvatica*	a1	10	61.5	10	75.5	2	0.1	4	0.6	2	0.8	2	4.8
	a2	-	-	-	-	1	0.1	7	11.2	1	0.1	8	28.0
V *Abies alba*	a	6	17.0	6	7.2	11	58.0	10	32.7	6	2.5	4	2.4
	b	8	15.5	6	4.9	11	20.3	9	17.2	8	21.6	6	4.6
V *Pinus sylvestris*	a	5	5.7	4	2.2	9	13.8	8	5.7	8	50.6	8	21.6
V *Quercus petraea*	a	2	0.1	2	0.1	5	2.2	6	10.7	4	6.9	4	11.3
III *Sorbus aucuparia*	b	9	2.9	7	2.8	11	6.3	8	5.0	6	5.0	6	2.8
V *Sambucus nigra*	b	-	-	1	0.1	-	-	5	6.7	1	0.1	3	0.5
V *Sambucus racemosa*	b	-	-	-	-	3	0.1	8	14.4	-	-	2	4.8
Ground layer													
I *Ch. Pino-Quercion*													
Luzula luzuloides		10	11.3	10	8.5	11	10.2	5	0.5	8	14.3	2	1.9
II *Ch. Vaccinio-Piceetalia*													
Vaccinium myrtillus		10	56.7	10	15.5	11	55.7	11	5.6	8	59.4	8	8.6
Orthilia secunda		10	0.8	3	0.2	10	0.9	1	0.1	7	1.1	1	0.4
Trientalis europaea		-	-	-	-	11	2.3	9	3.7	3	5.6	5	2.4
III *Ch. Vaccinio-Piceetea*													
Maianthemum bifolium		10	10.2	9	4.9	11	35.2	11	7.5	8	15.8	6	3.8
IV *Ch. Querco-Fagetea*													
Rubus hirtus		9	0.5	4	0.2	6	0.5	9	8.0	6	1.6	7	19.6
Lamiastrum galeobdolon		2	0.4	3	0.2	1	0.1	4	2.0	1	0.1	2	4.8
V Others													
Anthyrium filix-femina		9	1.0	8	2.1	11	1.4	11	11.5	6	2.8	7	6.8
Senecio fuchsii		2	0.1	4	0.2	2	0.1	8	15.8	1	0.1	1	0.1
Impatiens parviflora		-	-	3	1.6	-	-	7	8.1	-	-	3	2.3
Bryophytes													
I *Polytrichum formosum*		10	11.5	3	0.2	11	23.5	8	1.0	8	17.6	2	0.1
III *Pleurozium schreberi*		-	-	-	-	10	25.5	-	-	8	22.9	-	-

nizers. *Athyrium filix-femina*, *Dryopteris filix-mas*, *D. carthusiana* and *Oxalis acetosella* seem to be not sensitive or only slightly sensitive to the stress factors. On the contrary, plants of poor pasture and heathland (of the *Nardo-Callunetea* class), which formerly occurred sporadically in the *Pinus* variant of *Pino-Quercetum*, completely disappeared.

d) Comparison of changes in three variants of *Pino-Quercetum*. Thirty years ago three variants of *Pino-Quercetum* had (apart from the dominance of different tree species) a number of differential floristic features of their own. It is still possible to recognize these variants in the field, but the rank of differences between them became strongly reduced.

The *Fagus* variant (Table 3) was distinguished by a relatively low share of *Hieracium sabaudum*, as well as by the absence of *Hieracium laevigatum*, *Lycopodium annotinum*, *Melampyrum pratense* and *Pleurozium schreberi*. As most of these species disappeared recently from other variants of the association, this difference ceased to exist. The significant feature of the *Fagus* variant is still, however, the absence of *Trientalis europaea* and the presence of a number of species of mesic deciduous forests (of the *Carpinion* alliance) and of the xerothermic brushwoods (of the *Quercetalia pubescentis* order): *Daphne mezereum*, *Hepatica nobilis*, *Lathyrus niger*, *L. vernus*, *Melittis melissophyllum*, *Polygonatum odoratum*.

The *Abies* variant (Table 4) was distinguished from the two other variants by a more common occurrence of *Hieracium vulgatum*, *Lycopodium annotinum*, *Polygonatum verticillatum*, *Plagiothecium curvifolium*. It was the sole community in which *Sphagnum girgensohnii*, *Dryopteris dilatata* and *Mo-*

Table 7. *Abies alba* vitality in some stands of the *Pino-Quercetum* association in the Ojcow National Park (data for 1986).
^{x} strict reserves, (1) felled tree

Nos of phyto-sociological records (Table 4)	Numbers of trees with the share of green needles in the crowns of (%)					Abundance and sociability
	0	5-30	35-60	65-80	above 80	
2^{x}	8	1	12	4	0	2.2
4	0	4	13	8	0	3.3
5	0	(1)	7	13	4	4.3
8	1	5	11	8	0	3.3
11^{x}	5	3	10	7	0	2.1
12^{x}	5	4	11	4	1	4.3

neses uniflora occurred. Part of these species have not been found presently. In the *Pinus* variant (Table 5) some plants of relatively warm and dry forest sites occurred thirty years ago (*Cruciata glabra, Convallaria majalis*), as well as some species of open, oligotrophic communities of the *Nardo-Callunetea* class (*Calluna vulgaris, Genista tinctoria, Lycopodium clavatum, Potentilla erecta, Danthonia decumbens*). At present *Convallaria maialis* became very rare, and the other species of this group do not grow any more in the *Pinus* variant.

e) Dependence of mixed forest changes on local site conditions. Evident differences in the intensity and direction of vegetation changes exist between particular stands of *Pino-Quercetum* in the ONP. They seem to depend on an uneven distribution of air pollutants in the study area, as well as on different kinds of forest management intervention. These correlations, already discussed with regard to the tree decline (MEDWECKA-KORNAS et al. 1989, MEDWECKA-KORNAS and GAWRONSKI 1990), are also reflected by the lower vegetation layers. In the *Fagus* variant (Table 3) relatively well preserved stands with *Vaccinium myrtillus* in quite good condition were found in places protected against the western winds, carrying the highest amounts of pollutants (e.g. stand no. 12 with SE exposure in the central part of the Park, as well as stands no. 11 and 13 with S and NNE exposure, respectively, in the northern part of the Park (see Table 3 and Fig. 1). In the *Abies* and *Pinus* variants most significant changes of both the shrub layer and the ground layer were noticed in stands with most severely damaged coniferous trees. In the *Abies* variant (Table 4) such a situation was recorded e.g. in the stands located on the highest point in the central part of the Park (Zlota Gora, records 1 and 2), and on a local ridge with western exposure (record 11). A stand with relatively well preserved vegetation was found not far from plot 11, but lower on the slope exposed to the south (record 12). In the *Pinus* variant (Table 5) most stands are located on the plateau, outside of the strict reserves; they have been most severely disturbed by the forest management measures. Small areas with nearly typical character of the community still preserved, were found on southern and northern forest borders (stands with oak, *Quercus robur* or *Q. petraea*, and aspen, *Populus tremula*; records 9 and 10), and on flat areas above the rocks, in the transition zone to the plateau, at the eastern border of the Park (record 2'). The occurrence of the Scots pine in these places seems to be natural.

6. SHIFTS IN THE SHARE OF MAJOR SYNTAXONOMIC GROUPS OF SPECIES IN *PINO-QUERCETUM*

Changes in the floristic composition of *Pino-Quercetum* in the ONP may be synthetically expressed by using the taxonomic value of groups of species D (TUEXEN and ELLENBERG 1973). The relevant indices have been calculated separately for the records made 30 years ago and those made at present, and for each of the three variants (Table 8). After these data a general decrease in

Table 8. Changes in the taxonomic values of the groups of species (Tüxen and Ellenberg 1937) in the *Pino-Quercetum* association of the Ojcow National Park.

A records from 1958-59
B records repeated in 1986-88
C mean constancy of the group
D taxonomic value of a group of species
G collective participation of the given group
g total of the given group's occurrences
n number of records (cfr. Tables 3-5)
t total of occurrences of all the species in the table
z number of species of the given group

$$C\ (\text{in}\ \%)\ \frac{g}{z \cdot n} \cdot 100 \qquad G\ (\text{in}\ \%)\ \frac{g}{t} \cdot 100 \qquad D\ (\text{in}\ \%)\ \frac{C \cdot G}{100}$$

For further information see PAWLOWSKI et al. 1966.

	z		g		C		G		D	
	A	B	A	B	A	B	A	B	A	B
***Fagus sylvatica* variant** (n=10)										
Pino-Quercion	7	3	33	15	47.14	50.00	8.13	4.92	3.83	2.46
Vaccinio-Piceetalia	4	4	32	21	80.00	52.50	7.88	6.89	6.30	3.61
Vaccinio-Piceetea	5	5	46	36	92.00	72.00	11.33	11.80	10.42	8.50
Querco-Fagetea	27	24	130	104	48.15	43.33	32.02	34.10	15.42	14.77
Others	25	23	165	129	66.00	56.09	40.64	42.30	26.82	23.72
Total (t)	-	-	406	305	-	-	-	-	-	.
***Abies alba* variant** (n=11)										
Pino-Quercion	5	4	48	16	87.27	36.36	11.43	4.42	9.97	1.61
Vaccinio-Piceetalia	7	5	52	25	67.53	45.45	12.39	6.91	5.65	3.14
Vaccinio-Piceetea	11	10	75	44	61.98	40.00	17.86	12.15	11.07	4.86
Querco-Fagetea	14	16	37	77	24.03	43.75	8.81	21.27	2.12	9.31
Others	34	34	208	200	55.61	53.48	49.52	55.25	27.54	29.55
Total (t)	-	-	420	362	-	-	-	-	-	-
***Pinus sylvestris* variant** (n=8)										
Pino-Quercion	8	4	40	8	62.50	25.00	11.63	3.90	7.27	0.97
Vaccinio-Piceetalia	7	6	35	21	62.50	43.75	10.17	10.24	6.36	4.48
Vaccinio-Piceetea	8	7	39	20	60.94	35.71	11.34	9.76	6.91	3.48
Querco-Fagetea	16	17	44	54	34.38	39.71	12.79	26.34	4.40	10.46
Others	42	30	186	102	55.36	42.50	54.07	49.76	29.93	21.15
Total (t)	-	-	344	205	-	-	-	-	-	-

the number of species (z) during the last thirty years is evident (from 68 to 59 species in the *Fagus* variant, from 71 to 69 species in the *Abies* variant and from 81 to 64 species in the *Pinus* variant). The total sum of occurrences (t) decreased parallel. The taxonomic values of group of species (D) decreased evidently with regard to the species of the *Vaccinio-Piceetea* class, and still more dramatically for those of the *Vaccinio-Piceetalia* order and the *Pino-Quercion* alliance. On the contrary, the taxonomic values of the group of species representing the class *Querco-Fagetea* increased in both the *Abies* and *Pinus* variants, and remained unchanged in the *Fagus* variant. These figures strongly emphasize the profound recent transformations of the phytosociological character of *Pino-Quercetum* stands in the ONP.

7. POSSIBLE CAUSES OF VEGETATION CHANGES IN THE *PINO-QUERCETUM* ASSOCIATION

A large scale dieback of the forests is being actually observed in Europe and North America (CAPE et al. 1988, KLEIN and PERKINS 1987, MUELLER-DOMBOIS 1987, REBELE 1988, SCHLAEPFER 1989 and others).

The causes of this catastrophe are not yet determined. Relevant investigations concern the trees (e.g. LANDOLT and KELLER 1985, LOEHLE 1988, SMITH 1981, TURCSANYI 1988, ZIEGLER 1986). Studies on changes in the lower forest layers are rare; some of them, however, deal with the forest community as a whole (neutrophilous deciduous forests: FALKENGREN-GRERUP 1986, WILMANNS et al. 1986; neutrophilous forests and acidophilous oak-birch forests: KUHN et al. 1987; acidophilous pine forests: KAZMIERCZAKOWA 1987).

In the case of the Ojcow National Park the noxious impact of air pollution upon coniferous trees seems to be evident. There are many premises for such explanation of the rapid decrease in vitality and the death of many individuals of locally most sensitive species: *Abies alba* and *Pinus sylvestris*.

The plants in the lower forest layers are not only exposed to the air pollution, but depend also on other changeable factors, e.g. increased content of pollutants in precipitations dropping from the canopy layer (ZAJAC and GRODZINSKA 1980), or transported with the stemflow (JOCHHEIM 1986), changes in canopy structure and composition (which influence the litter fall and the light and soil conditions) and so on. Soil investigations conducted in the ONP 20 to 30 years ago were unfortunately not detailed enough to document changes in the edaphic conditions in the stands of *Pino-Quercetum*. Data published by GRESZTA and BITKA (1977), as well as those from outside of the Park by MED-

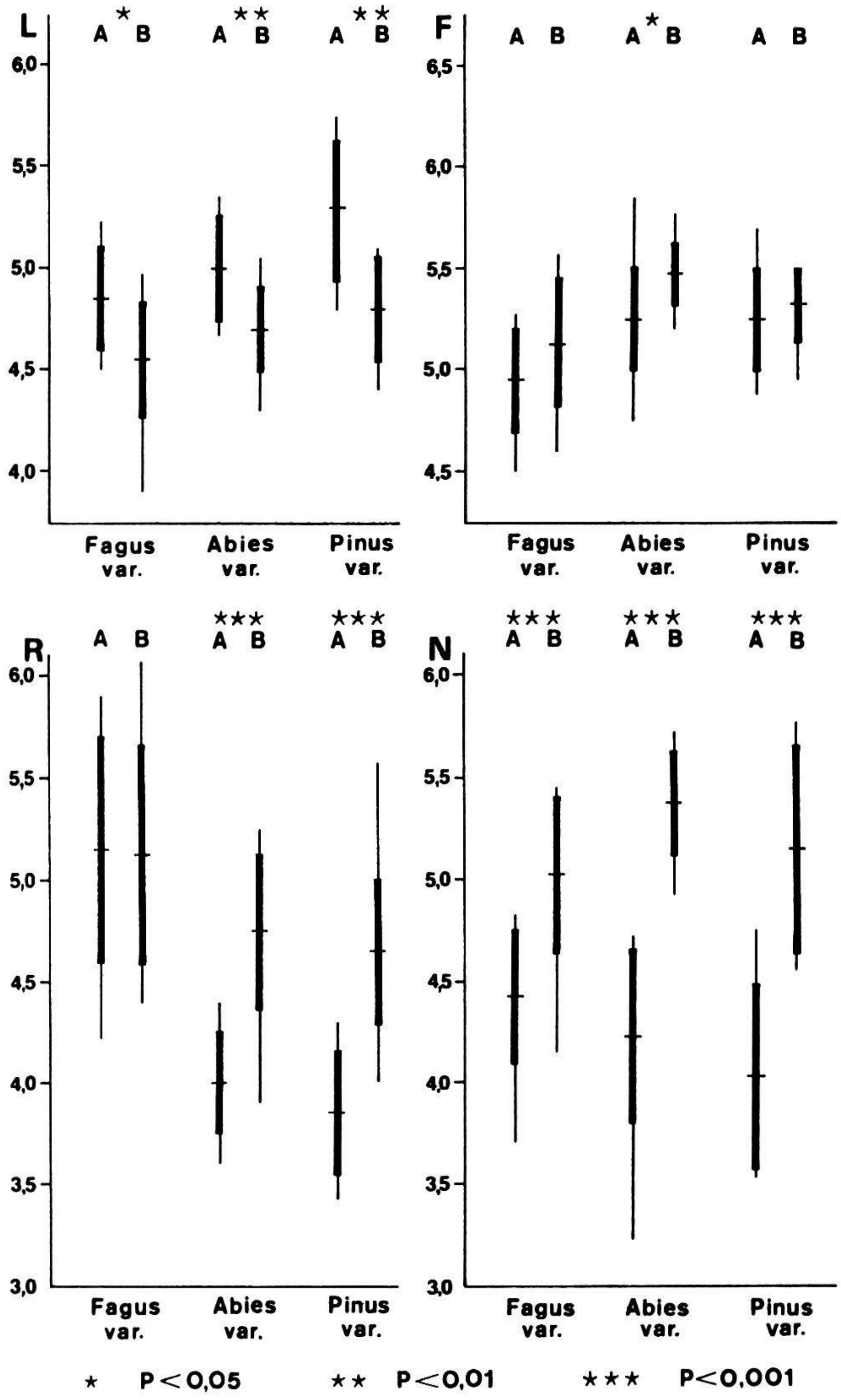

Fig. 2. Indicator values of vascular plants after ELLENBERG 1974, calculated for three variants of the *Pino-Quercetum* association in the Ojcow National Park.
L - light values, F - moisture values, R - reaction values, N - nitrogene values.
A - 1958-59 figures for the original set of records, B - 1986-88 figures for records repeated in some stands. For each group of records the mean, maximum and minimum values of the particular indicator are marked as well as standard deviations and the significance levels.

WECKA-KORNAS (1952) seem to indicate that the pH of the soil at that time was the same as at present. The influence of acid rain and soil acidification which is very important in other sites (e.g. in Scandinavia: ANDERSSON 1986, DAHL 1988, FALKENGREN-GRERUP 1986) is not evident in the Ojcow National Park.
Changes in soil conditions in the *Pino-Quercetum* stands of the ONP during the last thirty years can be inferred from the ecological indicator values of plants. For this purpose figures from ELLENBERG (1974) have been used (as e.g. by ROST-SIEBERT and JAHN 1988), with some supplementary data taken from ZARZYCKI (1984). For each individual species recorded in the former and/or present set of records the relevant figures of four indicator values (L, F, R, N) have been ascertained; then the mean indicator values for particular records have been calculated, and finally the mean values for complete sets of records for each variant and each of the study periods (Fig. 2). The light indicator values (L) generally decreased within the forests (save one stand of the *Abies* variant) and they do not seem to correlate with the thinning of the canopy layer by dieback of coniferous trees (as indicated in chapter 5a). This discrepancy resulted from the fact, that the shade-tolerant plants of the ground layer were effectively shaded by the increment of beeches or shrubs and tall perennial herbs and prospered well even in stands with recently thinned canopy - A_1. The soil moisture indicator values (F) pointed out (with a few exceptions) to the increase of soil humidity in the stands studied. These changes were statistically significant in the *Abies* variant. The soil reaction indicator values (R) in the *Fagus* variant remained on an average unchanged. However, in the *Abies* and *Pinus* variants they changed significantly indicating (with one exception) an increase. These figures confirm the lack of acidification processes, as suggested by direct soil measurements (see above). The increase of the pH values does not sufficiently explain the retreat of acidophilous species in the *Pino-Quercetum* of the ONP, because this retreat took place also in the *Fagus* variant, where the soil reaction did not change.
A very essential reason for vegetation changes has to be discerned in the accumulation of nitrogen in the forest environment. The indicator values for nitrogen (N) increased significantly in all studied stands, and consequently also in all three variants of *Pino-Quercetum*. In two cases the figures found presently were twice as high as thirty years ago. We certainly have to do with a far-reaching eutrophication of the forest habitats in the Park. It may result from the increased accumulation of dead matter on the forest ground, provided by dead trees, and/or from the increased content of nitrogen oxides in the atmosphere. The last factor is presently considered by many authors as the

main factor of disappearance of many rare (oligotrophic) species (ELLENBERG 1985) and the forest dieback in central Europe (ANDERSSON 1986, MANSFIELD 1988, WANG and SCHAAP 1988). KUHN et al. (1987) are of the opinion, that the present changes in the *Betulo-Quercetum* association in Switzerland, a vicariant community of the Polish *Pino-Quercetum*, resulted first of all from accumulation of nitrogen compounds from the atmosphere. The same is the opinion of WILMANNS et al. (1986) in relation to changes in some oak-hornbeam forests (*Querco-Carpinetum*) in Germany.

Even if eutrophication really is the main factor responsible for the changes in *Pino-Quercetum* of the ONP, other air pollutant cannot be neglected. High sulphur dioxide (SO_2) concentration in the atmosphere is certainly one of the most important among them (see chapter 2). It causes the accumulation of sulphur in the needles of the conifers (e.g. of *Abies alba*, SZCZEPANOWICZ oral information) and the high sulphate concentration in the water extracts from the bark of *Pinus sylvestris* (MEDWECKA-KORNAS et al. 1989). Another possibly important factor is the impact of heavy metals, first of all of lead and zinc, found in high concentrations in the wood of the beeches (KAZMIERCZAKOWA et al. 1984), in mosses (GRODZINSKA 1980) as well as in the dust fall in the ONP (see chapter 2). Other noxious elements (see chapter 2) may also contribute to the changes (SWIEBODA 1980). The toxic effects of heavy metal pollution were confirmed in a study of acidophilous pine forests (*Vaccinio myrtilli-Pinetum*) in the vicinity of zinc and lead smelting works near Olkusz, some 25 km WNW of Ojcow, where local forest community became completely desintegrated (KAZMIERCZAKOWA 1987). The dust-fall in this area contained not only heavy metals but also alkaline components responsible for the increase of soil pH, even to the neutral values. Experimental studies on the response of the ground layer vegetation in acidophilous forest stands to the environmental pollution were conducted in *Pino-Quercetum* of the Niepolomice Forest, about 40 km SE of Ojcow. Some study plots were treated with mineral fertilizers, the others with industrial dusts. Under the influence of NPK or NPK and dolomite input the share of *Vaccinium myrtillus* was reduced, the share of *Trientalis europaea* remained without distinct changes, and that of *Oxalis acetosella* markedly increased (MITKA 1987). The response of these species was thus similar as in the case of habitat eutrophication in the ONP. In the experiments with industrial dusts *Vaccinium myrtillus* proved to be tolerant to high zinc and cadmium doses, but particularly sensitive to the dust from cement works, which effectively increased the pH of the soil. *Oxalis acetosella* showed a negative reaction to the dust containing aluminium, zinc and cadmium in concentrations many times higher than that measured in the soils of the ONP. On the other hand, dust from cement works and from coal power station stimulated expansion of *Oxalis acetosella* (BRANIEWSKI and CHRZANOWSKA 1988). The knowledge of symbiotic connections in forest plants may possibly help to explain the intricate patterns of their reactions towards the environmental stresses. Experiments in the Niepolomice Forest revealed that in stands treated with fertilizers mycotrophism in the ground layer plants was greatly reduced - or even eliminated and the non-mycorrhizal plants, e.g. *Urtica dioica*, became dominant (KEDZIERSKA 1990). In plots treated with alkaline industrial dusts from cement works the mycorrhizal plants proved to be more sensitive than the others (TURNAU 1988). On the other hand, species of the family *Ericaceae* are more resistant to the heavy metals (BRADLEY et al. 1982). This resistance, however, may be reduced through the site eutrophication, which eliminates the mycorrhiza.

8. SYNTAXONOMICAL CONCLUSIONS

Due to the disappearance of species characteristic of *Pino-Quercetum* and its higher syntaxonomic units, the acidophilous mixed forest stands in the ONP do not represent any more this plant association. The individual stands became disintegrated to various degrees and in various ways, and do not have the stable character which they possessed before the rise of air pollution and the decline of coniferous trees. Therefore a revision of their syntaxonomic position is needed. The floristic premises, however, are not sufficient for distinction of a new plant association. It seems to be more reasonable to follow the suggestions of FALINSKI (1966) and OLACZEK (1974) and to distinguish only several stages of degradation of *Pino-Quercetum* (e.g. stands slightly, moderately and heavily disturbed). Such a classification indicates the origin of actually existing forest stands and their present site conditions (which still remain in many respects the same as in the former *Pino-Quercetum*). In some situations, however, a different approach seems to be more appropriate. Stands with increased share of neutrophilous forest plants characteristic of the *Querco-Fagetea* class and its subordinate syntaxa could already be regarded as fragmentary *Fagetalia* communities. Stands with thinned canopy and a large share of plants from the forest clearings could be classified as intermediate between the *Pino-Quercetum* and *Epilobietea angustifolii* communities. Solving all these problems is essential for repeating the vegetation mapping in the Park.

Disintegration of acidophilous forests associations is by no means limited to the Ojcow National Park. It is recorded from many other regions in Poland and abroad. In such situation the proposals concerning a revised classification of acidophilous mixed forests in Poland, with splitting the former *Pino-Quercetum* into numerous associations (MATUSZKIEWICZ 1984) seems to be little substantiated. This is also true of treating the *Fagus* variant of *Pino-Quercetum* as a separate association: *Luzulo nemorosae-Fagetum*, a proposal of MICHALIK (1987) which was not accepted in the present paper.

9. OUTLOOK

Preservation of the full diversity of forest communities, formerly existing in the Ojcow National Park, seems to be very difficult. This concerns the last remnants of acidophilous mixed forests, threatened by habitat eutrophication. Reduction of air pollution reaching the Park area seems to be conditio sine qua non of survival of the *Pino-Quercetum* association in this area. Such reduction on a general scale (as discussed e.g. by BACH 1985) forms at present the task of uttermost importance for environmental conservation.

SUMMARY

The Ojcow National Park (ONP), located in the vicinity of the industrial centres of Silesia and Cracow city, is submitted to a very heavy impact of air pollution, which causes a mass-dying of coniferous trees and other changes in the forest. These processes are most notable in the mixed acidophilous forest (*Pino-Quercetum*), studied in the ONP about 30 years ago (MEDWECKA-KORNAS and KORNAS 1963). In the present paper data concerning changes in soil properties in this forest association are submitted (Tables 1, 2), as well as unpublished phytosociological records from the years 1958-59 repeated in 1986-88 (Tables 3-5, Fig. 1). Differences between these two data sets are discussed and their possible causes are suggested. In the tree and shrub layer of the stands of *Pino-Quercetum* the share of silver fir (*Abies alba*) and Scots pine (*Pinus sylvestris*) considerably decreased (Tables 6, 7). The resulting gaps were filled by deciduous woody species. In the field layer, the formerly dominant *Vaccinium myrtillus* and carpet mosses markedly retreated, as also did *Orthilia secunda, Maianthemum bifolium* and other acidophilous species. *Lycopodium annotinum* disappeared completely. The share of the neutrophilous species of deciduous forests and cleared forest areas increased, and the newcomer *Impatiens parviflora* emerged in large quantities. In all variants of the association taxonomic values of the groups of species of *Vaccinio-Piceetea* class and its subordinate syntaxonomic units dropped down dramatically, and those of the *Querco-Fagetea* class increased considerably, especially in the *Abies alba* and *Pinus sylvestris* variants. Indicator values of vascular plants (after ELLENBERG 1974) confirm a significant increase of nitrogen content, i.e. an eutrophication of forest soils (Fig. 2), resulting from the immissions of nitrogen oxides (the NO_2-concentration in the air in the Ojcow N.P. exceeds e.g. by 10 times that in the Białowieża N.P., NE Poland). Nitrogen pollution in the ONP is running parallel to other pollu-

tants: SO_2, heavy metals, etc. To prevent further disintegration of the *Pino-Quercetum* association in the Ojcow area an essential reduction of the present air pollution level is necessary.

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