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ECOLOGICAL AND STATISTICAL ANALYSIS OF HERB LAYER IN THE CONTACT ZONE OF ASSOCIATIONS PEUCEDANO – PINETUM MAT. (1962) 1973 AND QUERCO – PICEETUM (MAT. ET POL. 1955)

ABSTRACT: Spatial structure of herb layer vegetation was investigated in the contact zone of two forest phytocoenoses as well as the breadth and character of this zone. The breadth of transitory zone was 4 m (a border very distinct in character). In this zone the plant species of both neighbouring phytocoenoses were mixed together without a new community which could be distinguished. Habitat conditions were investigated simultaneously showing some correlation among the soil abundance in some mineral components of soil, ground water level, soil sub-type and species composition of the herb layer vegetation.

KEY WORDS: Transitory zone, band transect, forest phytocoenosis, herb layer.

Contents

1. INTRODUCTION

The problem of borders between plant communities has been examined by many scientists, but their opinions vary and sometimes are even contradictory. According to some authors (W a n g e r i n 1925, K y l i n 1926, S u k a č e v 1930, R a m i e ɲ s k i j 1938) the transitions are hardly visible and gradual so the borders can be hardly found, whereas other authors claim that the borders between phytocoenoses are distinct and sharp and the transition takes place on a small area (C a j a n d e r 1910, G l e a s o n 1917, D u R i e t z 1921, 1928, K u j a l a 1929). Some phytosociologists are of an opinion that there is a great variety of contact zones between associations and that they frequently have a "mosaic-insular" character due to heterogeneous habitat conditions (N i c e n k o 1948, T r a c z y k 1960, P o l a k o w s k a 1966). Another opinion is that of Scharfetter (1932) (after T r a c z y k 1960) that the transitory zone is a third phytocoenosis, which is a mixture of neighbouring elements, or a separate community called "contact formation". Also P a c z o s k i (1925), S ł a w i ń s k i (1950) and M a t u s z k i e w i c z (1972) have been studying the problem of various breadth of borders and the kind of contact between two phytocoenoses, pointing out that the final statement requires detailed comparative studies, where similar methods would be used for various pairs of phytocoenoses.

When discussing the problem of transitory zones, attention should be paid to correlation between the vegetation cover and the habitat, and also to the factor of competition among species forming the neighbouring plant communities. There are great divergences as regards those opinions, due to the absence of detailed and comparable investigations and diversity of meaning of the concepts and terms used. The majority of authors agree as to the correlation of the system vegetation-habitat (P a c z o s k i 1925, K y l i n 1926, N i c e n k o 1948, K r a n k o w s k a--S z n a j d e r 1951, T r a c z y k 1960, P o l a k o w s k a 1966, M a t u-s z k i e w i c z 1972). This thesis is opposed mainly by Scandinavian scientists, according to which even smooth changes of intensity of habitat factors do not affect the sharpness of borders between communities (K u j a l a 1929).

T r a c z y k (1960), M a t u s z k i e w i c z (1972) and F a l i ń s k a (1974, 1979) have contributed the most to studies on contact zones. By means of the method of band transect together with vegetation charting on a large scale and soil analyses T r a c z y k (1960) has tried to determine the character and structure of the contact zone between two neighbouring communities, the relations among some habitat factors and the breadth of this zone as well as the relation between floristic affinity of phytocoenoses and the kind of border between them. He has found that the border zone does not have a typical community, being either a mixture of components of neighbouring systems or a qualitatively separate unit, whereas the gradually changing habitat factors lengthen the transitory zone and produce a syntaxonomically separate community. When these factors change on a small area a separate unit is not created.

According to M a t u s z k i e w i c z (1972) phytocoenoses change into one another in a continuous way as a principle, but they show some relative discontinuums. Thus the elements of one cummunity mix with those of another in a different quantitative proportion and form a kind of zone. This zone has areas, which cannot be considered definitely as belonging to one of the two phytocoenoses, and only a quantitative characteristic as regards the contribution of elements of both phytocoenoses is possible. Thus, the author suggests to determine such principle of organization of ecological systems as a relative discontinuum, at the same time ignoring the hypothesis of absolute continuum and discontinuum as a method of mergence of two different phytocoenoses.

The studies of Falińska (1974, 1979) have concerned the reaction of plant populations to differentiation of ecosystems and ecotone systems. Thus, considerable differences were observed among individuals of a given species living in ecotones and individuals in the neighbouring ecosystems. Also, when using phytosociological methods together with those applied in population studies it is possible to determine the borders of populations of neighbouring ecosystems.

The present study has been conducted in order to analyse ecologically and statistically the contact zone of two forest phytocoenoses, to determine habitat factors responsible for their neighbourhood and to find how the mergence of these two ecological systems occurs. Because of the theoretical and practical significance of the contact zone and the correlation of the system vegetation-habitat, the aim here is to present further comparative material in order to study better the problems that have been mentioned.

2. CHARACTERISTICS OF THE AREA AND METHODS OF INVESTIGATIONS

Field investigations were conducted in July 1981 on the area of the previously planned forest reserve Zwierzyniec in Roztocze National Park (Fig. 1). According to the physiographical division of former Lublin province (Chałubińska and Wilgat 1959) this park belongs to the central Roztocze region. The forest reserve is 3 km to the south-east of Zwierzyniec village. Izdebski (1972) has given a more detailed phytosociological characteristic of the area investigated.

Attention has been paid to the contact zone between associations Peucedano – Pinetum Mat. (1962) 1973 and Querco – Piceetum (Mat. et Pol. 1955) in the western part of forest inspectorate, sector 119.

The tree cover of association Peucedano – Pinetum consists of 60-years old pine with a slight admixture of spruce and birch. The shrub layer is rather poor, and in the herb layer characteristic species of the order Vaccinio – Piceetalia prevail. As regards the physiognomy and floristic composition association Peucedano – Pinetum from the former forest reserve Zwierzyniec does not differ from this type of forest associations in central and southern Roztocze region described by Izdebski (1962, 1966).

The structure and floristic composition of association Querco – Piceetum are similar to other fragments of this association described by Matuszkiewicz and Polakowska (1955), Polakowski (1961), Izdebski (1963). The layers of trees and shrubs are formed mainly by the spruce, shading some areas and causing serious disturbances in floristic relations within the herb layer. *Lycopodium*

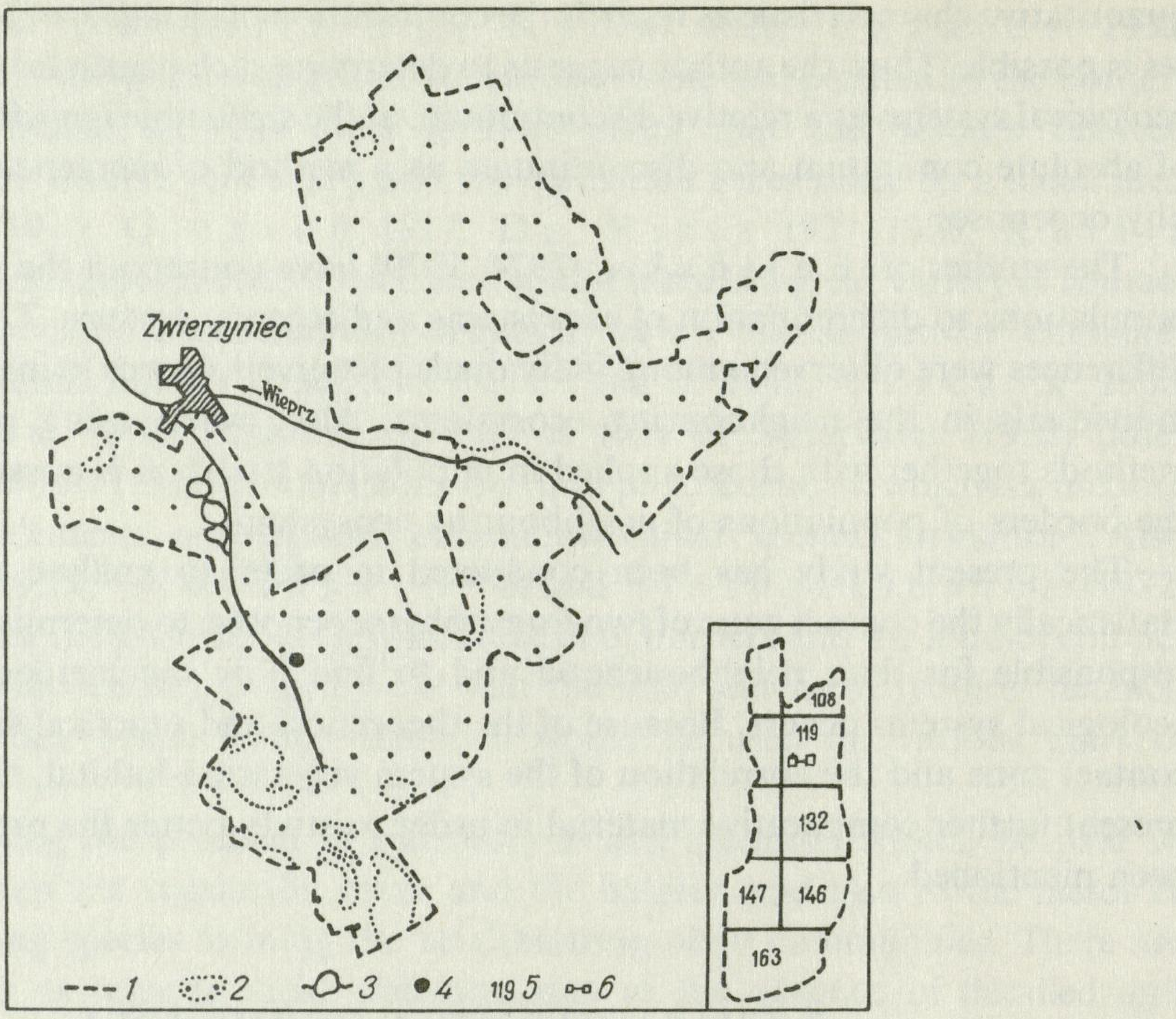

Fig. 1. Map of Roztocze National Park and of the planned forest reserve "Zwierzyniec"
1 – border of Roztocze National Park and of the forest reserve, 2 – forest areas, 3 – watercourses and water bodies, 4 – area investigated, 5 – numbers of sectors, 6 – surface areas of records and the transect

annotinum L. and *Oxalis acetosella* L. dominate there in the herb layer and are accompanied by abundantly growing mosses of pine forest. In the hollow parts of the area peatmosses form tufts. The western border of association Querco – Piceetum adjoins the fragment of alder forest growing on the banks of a small watercourse running across the forest reserve. In the direction from Peucedano – Pinetum to Querco – Piceetum the area slowly declines and the difference in the level of the patches of two associations examined is about 60 cm.

The contact zone was analysed using the method suggested by M a t u s z k i e w i c z (1972). Between typical patches of association Peucedano-Pinetum and Querco – Piceetum a straight transect was made, consisting of a series of squares of a surface area 4 m^2, close to one another. In each square the presence of each species of herb layer plants was recorded. The transect was 50 m long and 2 m broad. It had 25 squares, numbered in their running order; beginning in the phytocoenosis of Peucedano – Pinetum and ending in Querco – Piceetum. In every second square soil pits were dug and they reached the ground water level. Profiles were described, soil samples were taken from each genetic horizon, in other squares soil samples were taken from each genetic horizon to the depth of about 50–55 cm.

Analyses of soil samples, made according to commonly accepted methods, included: mechanical composition – Casagrande's areometric method modified by Prószyński, organic matter content – combustion in muffle kiln, humus content – Tiurin's method, $CaCO_3$ content in Scheibler's apparatus, soil acidity – electrometrically. Furthermore determined were: ammonium nitrogen – Kjedahl's method, nitrate nitrogen – with brucine, potassium, sodium and calcium – in flame photometer, phosphorus – with photo-rex, iron – with o-phenatroline, and magnesium – with titanium yellow. The results of some analyses (potassium, phosphorus, iron, ammonium nitrogen) concern the soil properties in the raw humus sub-horizon A_{FH}, in humus horizon A_1 and in horizon of accumulation of mucky humus A_1M as they are the most essential for the root zone of herb layer plants. Results of other analyses are not given, because soil parameters on the whole transect did not display significant differences.

In typical patches of both associations one phytosociological record was made using the Greig-Smith's square. A square 16 × 16 m (256 m^2) was divided into 64 squares of a surface area 4 m^2 (2 × 2 m). Plant species of herb layer were recorded for each square. In both patches soil pits were dug, described and soil samples were analysed.

Thus obtained material was arranged statistically and analysed floristically. This was done in two stages: analysis of both typical fragments of associations, then a floristic and statistical analysis of the transect and comparison of results with those of soil studies.

A n a l y s i s o f p h y t o c o e n o s e s. In both records the frequency for each species was calculated in per cents and then the absolute differences in frequency D_0:

$$D_0 = (f_1 - f_2)$$

In order to check the significance of the difference D_0 was compared with the limit $D_{0.01}$, calculated according to the equation:

$$D_{0.01} = t_{0.01}\sqrt{p \times q\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

where $p = \frac{f_1 + f_2}{2}$; $q = 100 - p$; n_1 and n_2 – abundance in samples allowing to calculate frequency (64); $t_{0.01}$ – value read from the table of distribution of t Student's function for the confidence level 99% at $v = n_1 + n_2$ degrees of freedom. If $D_0 > D_{0.01}$ then at the error's risk 1% this difference is considered significant. The results were used in tables of frequency of species, dividing them into species of a significantly higher frequency in association Peucedano – Pinetum, species of a significantly higher frequency in association Querco – Piceetum and equal in numbers and sporadic species.

Coefficient D_0 was the basis for calculating information values for association Peucedano – Pinetum (I_a) and Querco – Piceetum (I_b).

$$I_a = \sum D_a \qquad I_b = \sum D_b$$

Mean information values of both associations investigated were calculated and given symbols: $\bar{I}_a$ and $\bar{I}_b$.

For all basic research areas (4 m^2) value W was calculated, which characterizes the contribution of species significant for Peucedano – Pinetum and Querco – Piceetum:

$$W_a = \frac{I_a}{I_a + I_b} \qquad W_b = \frac{I_b}{I_a + I_b}$$

Mean values $\bar{W}_a$ and $\bar{W}_b$ were calculated for both associations.

A n a l y s i s o f t r a n s e c t. All species of herb layer plants occurring within the transect were divided into three groups as regards their frequency, similarly as on the surface areas of basic records.

For each square magnitudes of information I_a and I_b were calculated. These indices and mean values $\bar{W}_a$ and $\bar{W}_b$ were used to calculate the relative value W^* and the representativeness of R:

$$W_a^* = \frac{I_a}{(I_a + I_b)\bar{W}_a} \qquad W_b^* = \frac{I_b}{(I_a + I_b)\bar{W}_b}$$

The relative value shows the relative contribution of each phytocoenosis to the given square of the transect as compared with conditions in records. The representativeness shows the percentage of elements of each phytocoenosis in the herb layer of the given square of the transect. R values were calculated according to the following equations:

$$R_a = \frac{I_a}{\bar{I}_a} 100\% \qquad R_b = \frac{I_b}{\bar{I}_b} 100\%$$

In order to see fully the floristic relations within the transect coefficients of floristic similarity between squares were calculated using Sörensen's equation (Č e š k a 1968). The results are presented by means of Czekanowski's diagram.

3. RESULTS

3.1. ANALYSIS OF ASSOCIATIONS

The surface of the record in association Peucedano – Pinetum shows 24 species of herb layer plants. The frequency of ten of these species has been considered as distinguishing the association examined (Table I). The maximal number of species in a square (2 × 2 m) was 14, the most numerous were squares with 8–11 species. Mean information value for Peucedano – Pinetum $\bar{I}_a = 171.8$, and mean value $\bar{W}_a = 0.86$. The patch of association Peucedano – Pinetum examined grows on proper podsolic soil formed of coarse sandy soil.

Table I. Species occurring in basic records of associations Peucedano-Pinetum and Querco-Piceetum

Species	f_1 %	f_2 %	D_o %
Species having significantly higher frequency in Peucedano-Pinetum (f_1)			
Melampyrum pratense L.	65.5	–	65.5
Hylocomium splendens (Hedw.) Br. eur.	40.6	6.2	34.4
Pteridium aquilinum (L.) Kuhn.	95.3	64.0	31.3
Luzula pilosa (L.) Willd.	98.4	68.7	29.7
Vaccinium vitis-idaea L.	100.0	73.4	26.6
Picea excelsa (Lam.) Lk. c	42.1	17.1	25.0
Leucobryum glaucum (Hedw.) Schimp.	15.6	1.5	14.1
Pleurozium schreberi (Willd.) Mitten	100.0	89.0	11.0
Calluna vulgaris (L.) Salisb.	10.9	–	10.9
Pinus sylvestris L. c	10.9	–	10.9
Species having significantly higher frequency in Querco-Piceetum (f_2)			
Oxalis acetosella L.	–	100.0	100.0
Lycopodium annotinum L.	–	93.7	93.7
Dryopteris spinulosa (Müll.) O. Kuntze	20.3	87.5	67.2
Majanthemum bifolium (L.) F. W. Schm.	31.2	78.1	46.9
Mnium affine Bland.	–	35.9	35.9
Plagiothecium laetum B. S. G.	–	32.8	32.8
Dryopteris austriaca (Jacq.) Woynar	–	26.5	26.5
Polytrichum formosum Hedw.	20.3	43.7	23.4
Rubus idaeus L.	–	17.1	17.1
Species equal in numbers in both records or sporadic			
Vaccinium myrtillus L.	100.0	92.1	7.9
Trientalis europaea L.	98.4	93.7	4.7
Dicranum undulatum Turn.	28.1	15.6	12.5
Sorbus aucuparia L. c	6.2	4.6	1.6
Moehringia trinervia L.	1.5	3.1	1.6
Fagus silvatica L. c	4.6	4.0	0.6
Molinia coerulea (L.) Moench.	6.2	–	6.2
Quercus sessilis Ehrh. c	3.1	–	3.1
Frangula alnus Mill. c	1.5	–	1.5
Pohlia nutans Lindb.	1.5	–	1.5
Milium effusum L.	–	9.3	9.3
Sphagnum nemoreum Scop.	–	7.8	7.8
Carex canescens L.	–	3.1	3.1
Betula pubescens Ehrh. c	–	1.5	1.5
Rubus plicatus W. et N.	–	1.5	1.5
Urtica dioica. L.	–	1.5	1.5

The surface of the record in association Querco – Piceetum shows 28 species of herb layer plants. The frequency of 9 of these species was significantly higher in this association (Table I). The greatest number of species on the basic research area was 17, the most numerous were squares with 11 species. Mean information value was $\bar{I}_b = 372.2$, and mean value $\bar{W}_b = 0.81$. The phytocoenosis of Querco – Piceetum grows on mucky podsolic soil formed of loose sandy soil with ground gley features on eluvial and iluvial horizons.

Analysis of soil from typical patches of two associations did not show significant differences of properties examined. Considering the high stepwise variability of soil parameters in the transect there were only significant differences in contents of potassium, phosphorus, iron and ammonium nitrogen. These parameters were almost twice higher in Querco – Piceetum.

The results obtained allow to compare the two typical phytocoenoses. Both associations differ in their species composition of herb layer plants and each has local distinguishing species. The associations examined grow on soil belonging to two different subtypes. But as regards the numbers of species on the surface of records (256 m^2) and species typical of the phytocoenoses there was a great similarity.

3.2. ANALYSIS OF THE TRANSECT

Floristic material from the transect is arranged in Table II. The Table presents the occurrence of particular species, their number in a square and also the number of species including the division into groups as regards frequency, and the percentage of particular groups in the total number of species in a square. Data in Table II are useful when analysing the herb layer vegetation on the transect.

The number of herb layer plants on basic research areas (Fig. 2) fluctuated between 9 and 16, but the squares belonging to Querco – Piceetum were floristically more abundant. The decline in numbers on squares 21 and 22 was due to great density of spruce brushwood, shading the area.

The percentage of local species distinguishing both associations changed greatly along the transect (Fig. 3). On squares 1–10 species of Peucedano – Pinetum were about 60% of all herb layer, on further squares their percentage was decreasing considerably to become finally 20% at the end of the transect. In the first squares of the transect there was about 10% of local species distinctive for Querco – Piceetum. From square 11 onwards their percentage in herb layer increased rapidly to 50% in square 17 and remained similar in the further section of the transect.

When analysing the variability of indices of relative value W^*, representativeness R and floristic similarity of squares (Figs. 4–6) 4 sections can be distinguished along the transect.

S e c t i o n I (squares 1–10). Typical herb layer of association Peucedano – Pinetum. Great similarity of squares, very high indices of association Peucedano – Pinetum – W_a^* and R_a, but very low indices of association Querco – Piceetum W_b^*

Table II. Plant species in successive squares of the transect*

Species	No. of square																									*n*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Number of species in a square	13	12	12	11	12	11	10	9	9	9	11	13	11	13	13	15	14	14	16	11	11	12	14	14	12	
Species having a significantly higher frequency in Peucedano-Pinetum																										
Pleurozium schreberi (Willd.) Mitten	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	–	24
Luzula pilosa (L.) Willd.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	–	–	x	x	x	x	23
Vaccinium vitis-idaea L.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	–	–	–	–	x	x	21
Pteridium aquilinum (L.) Kuhn.	x	–	x	–	x	x	x	x	x	x	x	x	–	–	x	x	x	x	x	x	x	–	x	x	x	20
Hylocomium splendens (Hedw.) Br. eur.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	–	–	–	–	–	–	–	–	–	16
Melampyrum pratense L.	x	x	x	–	x	x	x	x	x	–	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–	9
Calluna vulgaris (L.) Salisb.	x	x	x	x	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Picea excelsa (Lam.) Lk. c	–	–	–	–	–	x	–	–	–	x	–	x	–	–	–	x	–	–	–	–	–	–	x	–	–	5
Leucobryum glaucum (Hedw.) Schimp.	–	–	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Abies alba Mill. c	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Total *x*	8	6	7	6	7	7	6	6	6	6	5	7	4	4	5	6	4	4	4	2	2	2	4	3	3	
Per cent	62	50	58	55	58	64	60	67	67	67	45	54	36	31	38	40	29	29	25	18	18	17	29	21	25	
Species having a significantly higher frequency in Querco-Piceetum																										
Polytrichum formosum Hedw.	x	x	x	x	x	x	–	x	x	x	–	–	x	x	x	x	x	x	x	x	–	x	x	x	x	21
Lycopodium annotinum L.	–	–	–	–	–	–	–	–	–	–	x	x	x	x	x	x	x	x	x	–	x	x	x	x	x	14
Oxalis acetosella L.	–	–	–	–	–	–	–	–	–	–	–	x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Dryopteris spinulosa (Müll.) O. Kuntze	–	–	–	–	–	–	–	–	–	–	–	–	x	x	x	x	x	x	x	x	x	x	x	x	x	13
Majanthemum bifolium (L.) F. W. Schm.	–	–	–	–	–	–	–	–	–	–	–	x	–	–	x	x	x	x	x	x	x	x	x	x	x	12
Mnium affine Bland.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	x	x	x	x	x	x	x	x	x	9
Plagiothecium laetum B. S. G.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	x	x	x	x	–	–	–	x	–	5
Rubus idaeus L.	–	–	–	–	–	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Total *x*	1	1	1	1	1	1	1	1	1	1	1	3	4	4	5	5	7	7	7	6	5	6	6	7	6	
Per cent	8	8	8	9	8	9	10	11	11	11	9	23	36	31	38	33	50	50	44	55	45	50	43	50	50	

*Not differentiating species are not included in the Table.

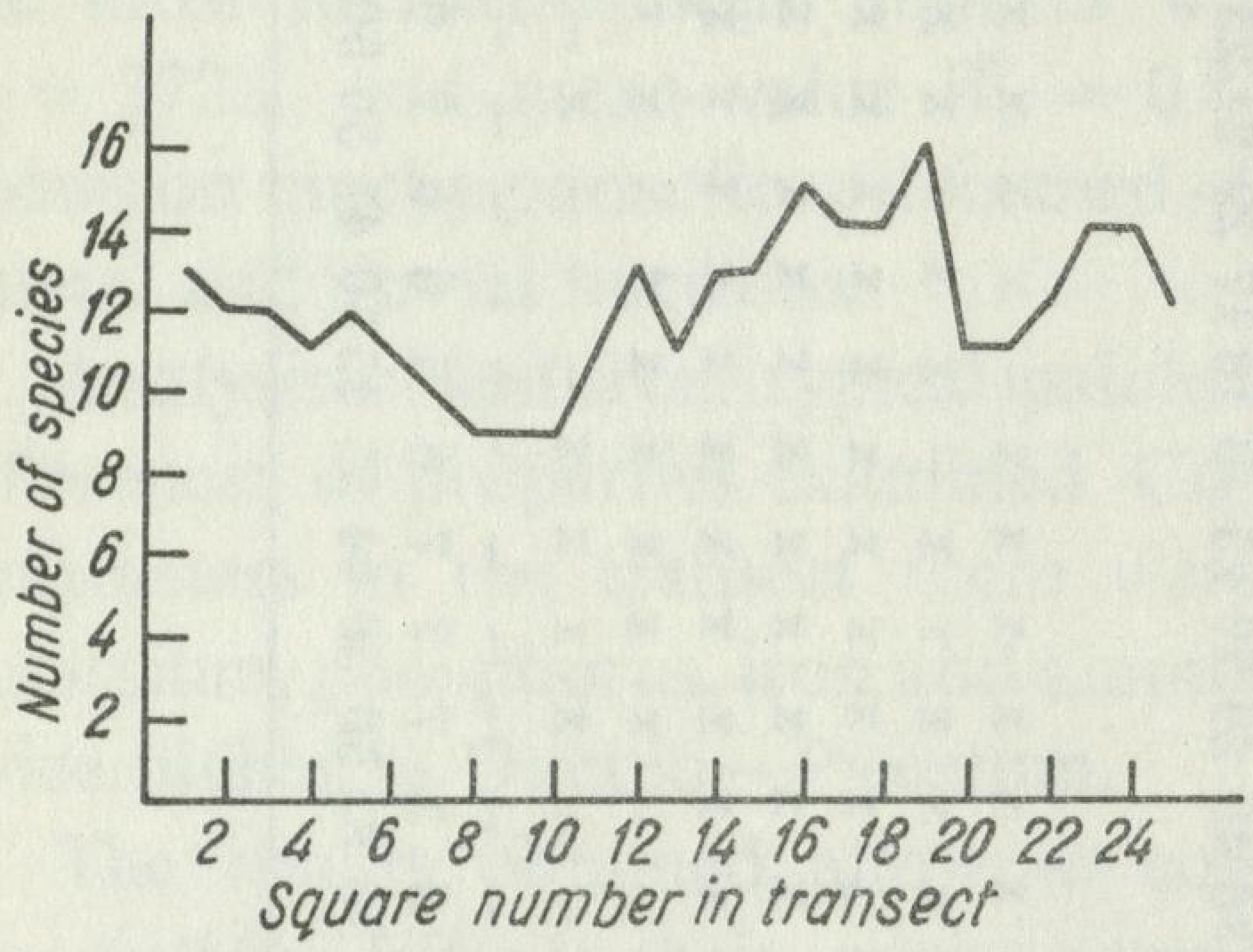

Fig. 2. Number of species of herb layer plants on basic research areas of the transect

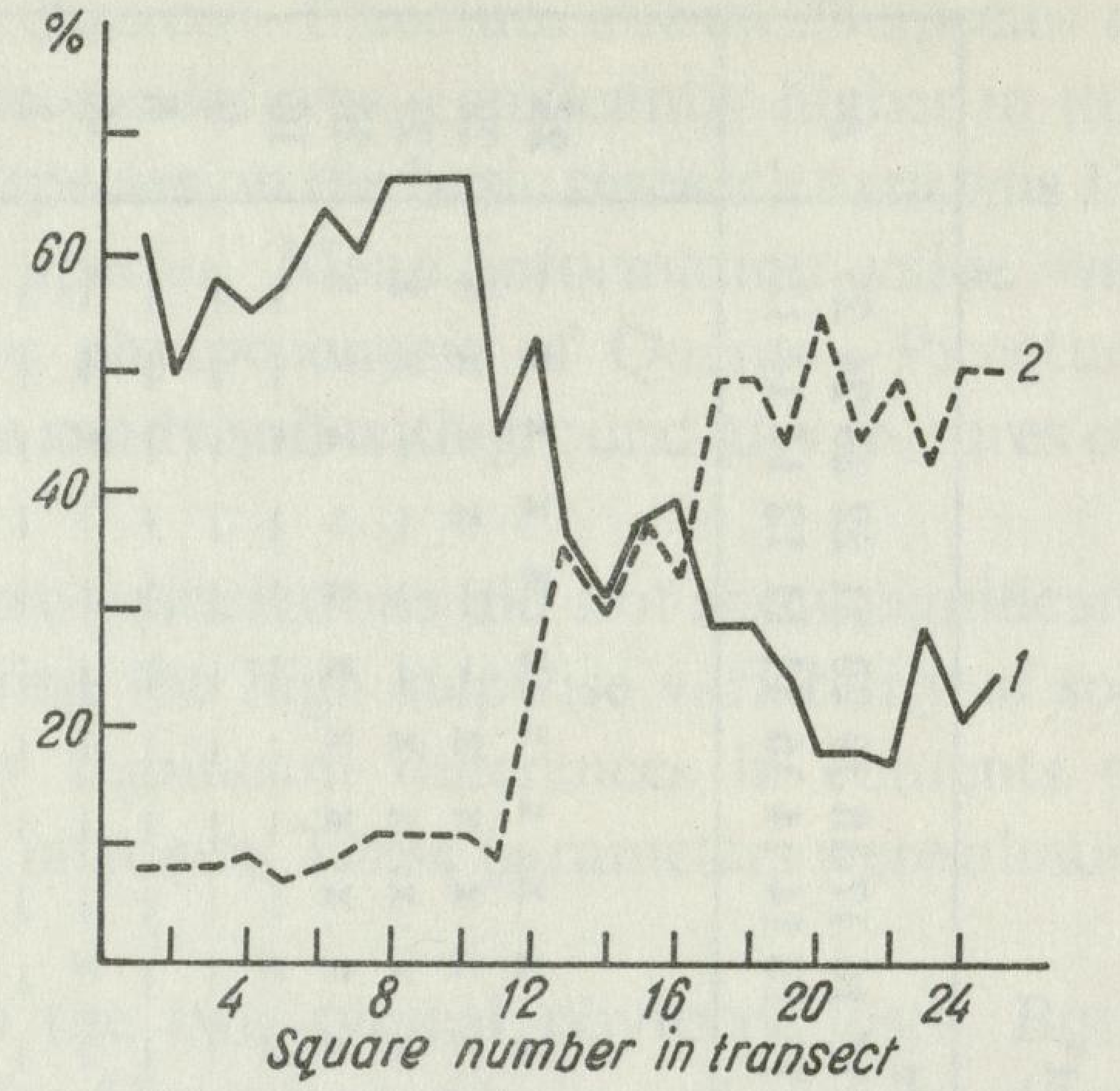

Fig. 3. Percentage of local species distinguishing both associations in successive squares of the transect

1 – species distinguishing the association Peucedano – Pinetum, 2 – species distinguishing the association Querco – Piceetum

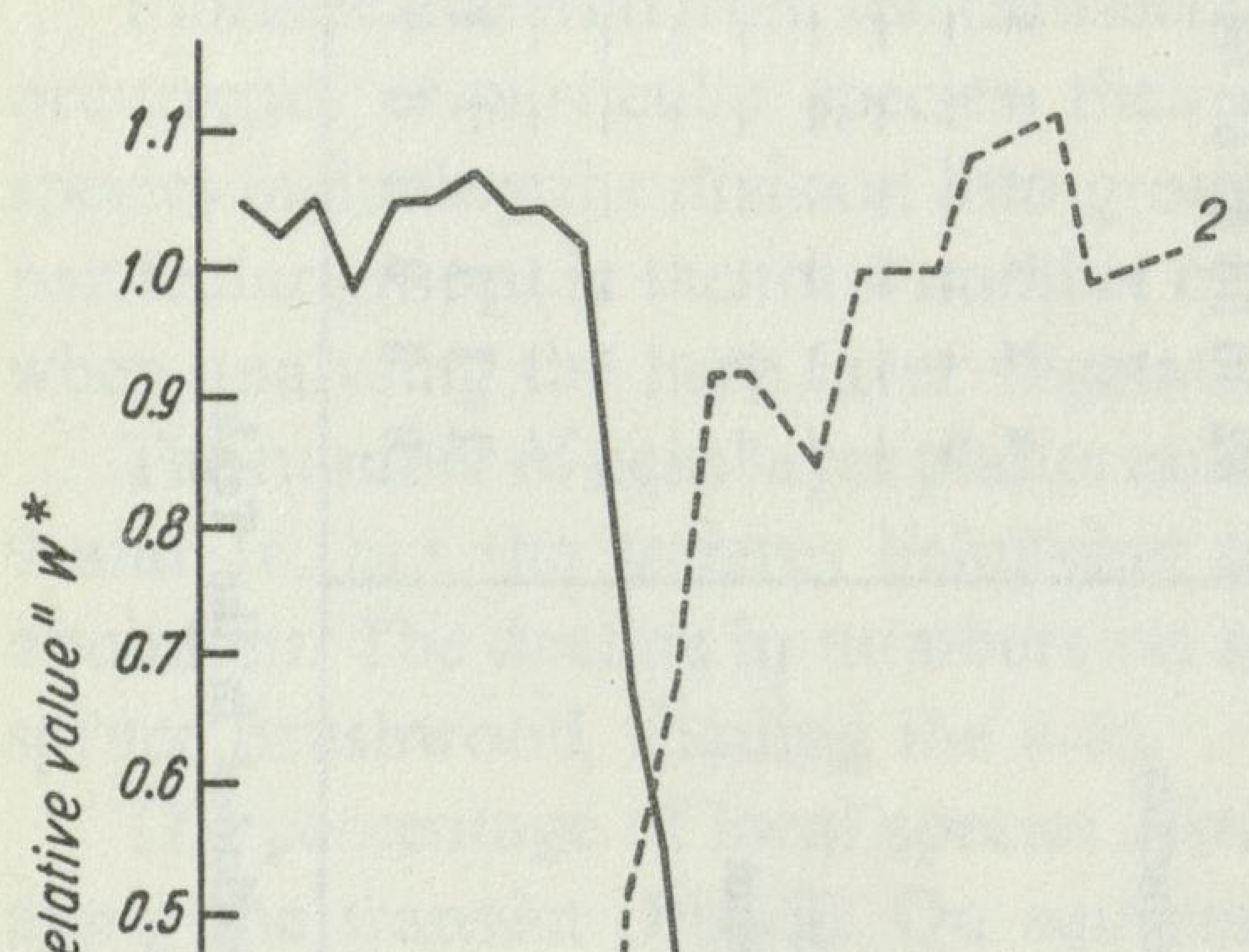

Fig. 4. Spatial variability of indices W_a^* and W_b^* on the transect

1 – W_a^*, 2 – W_b^*

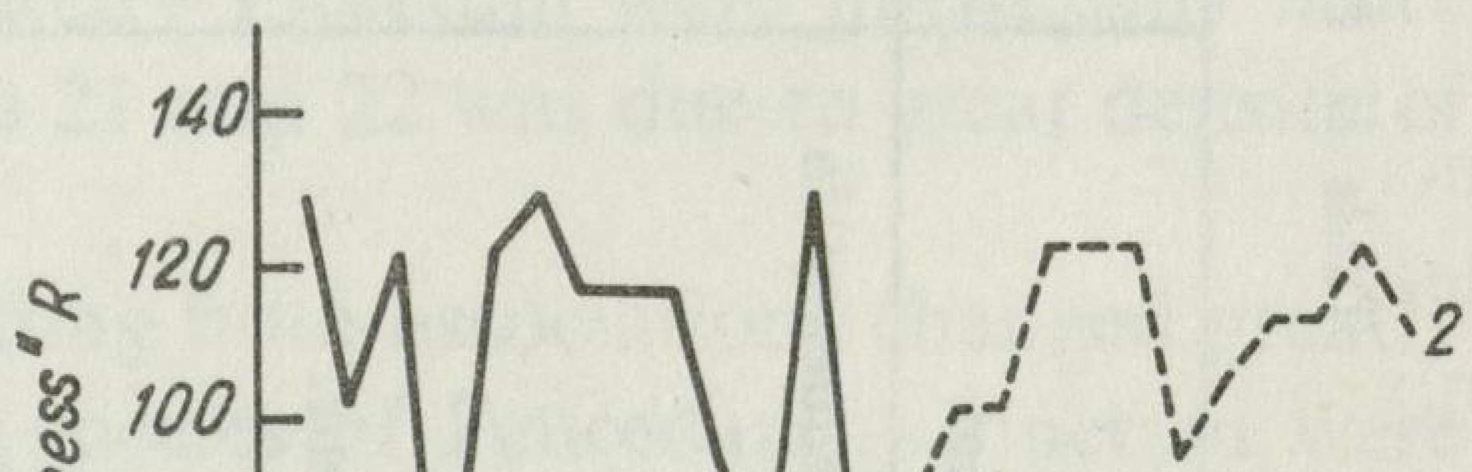

Fig. 5. Spatial variability of indices R_a and R_b on the transect

1 – R_a, 2 – R_b

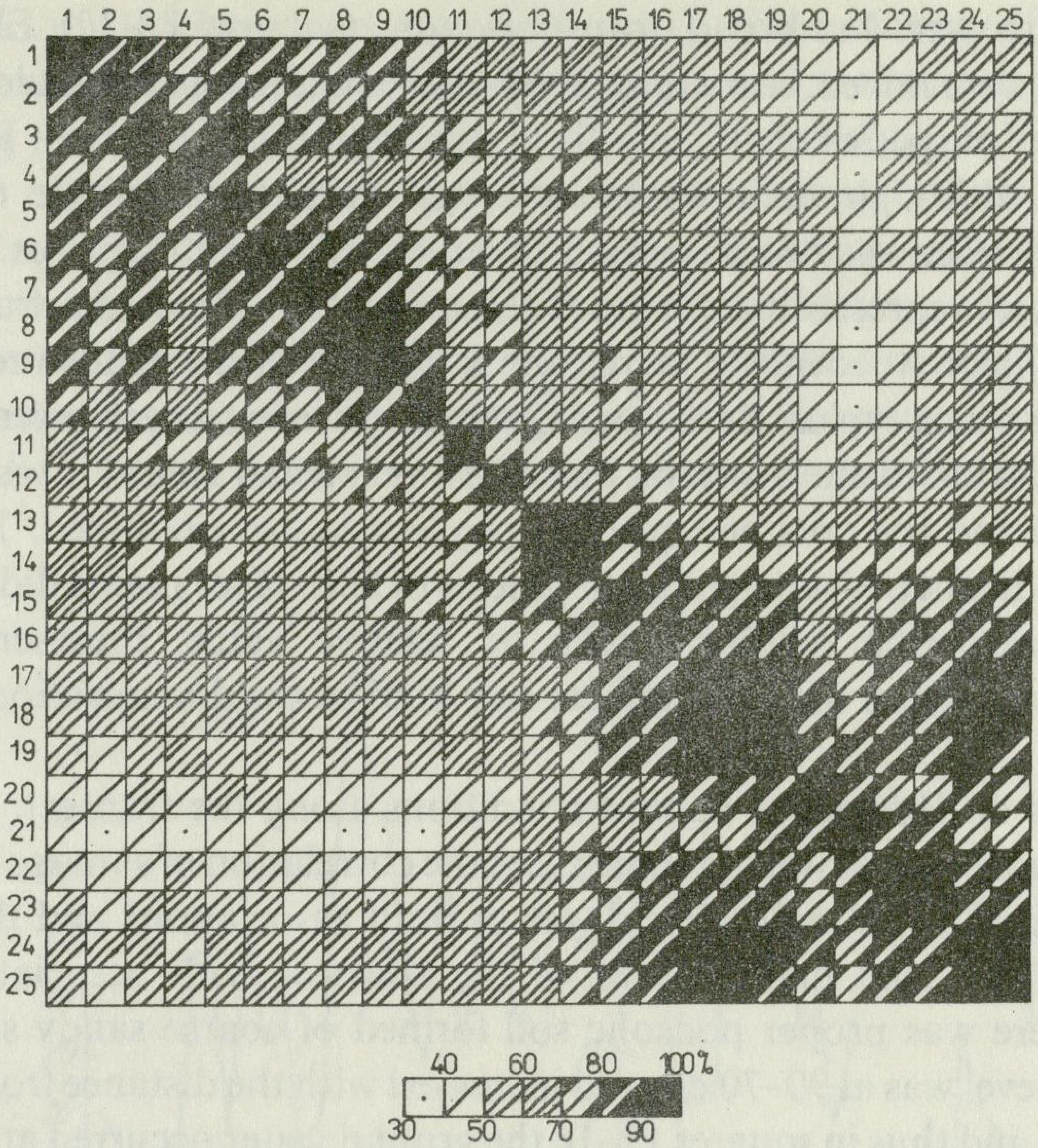

Fig. 6. Diagram of floristic similarity of squares on the transect
1–25 – numbers of squares of the transect

and R_b. Small influence of neighbouring phytocoenosis in this section. Large concentration of shrubs inhibited the growth of herb layer on square 4.

S e c t i o n II (squares 11–12). Great floristic similarity of squares. Rapid increase of indices of association Querco – Piceetum – W_b^* and R_b, considerable decrease of value W_a^*. Index R_a remained at a high level. Relatively equal proportion of mixed species of associations Peucedano – Pinetum and Querco – Piceetum.

S e c t i o n III (squares 13–16). Small differences among squares. Indices of association Querco – Piceetum – W_b^* and R_b – increased slightly, remaining at a high level. Indices of association Peucedano – Piceetum – W_a^* and R_a – decreased. These squares represented typical developed layer of association Querco – Piceetum with a considerable admixture of species of association Peucedano – Pinetum having a broad ecological amplitude.

S e c t i o n IV (squares 17–25). Great floristic similarity of squares. At low indices of association Peucedano – Pinetum W_b^* and R_b were high. This section had fully developed herb layer of association Querco – Piceetum not showing any special influence of association Peucedano – Pinetum.

The transect had a 12 m contact zone, covering squares 11 – 16, where plant species of neighbouring associations had been mixed in various proportions. Within that zone there was a narrower, 4 m broad, transitory zone (squares 11–12). Elements of both phytocoenoses were mixed, remaining in relative equilibrium. It should be pointed out that the number of species characteristic of association Peucedano – Pinetum decreased gradually, although their admixture was quite considerable even in typical developed phytocoenosis of association Querco – Piceetum (squares 13–16). But the number of species representing the association Querco – Piceetum was quite small in the neighbouring phytocoenosis, increasing rapidly in the transitory zone and so from square 13 there was a typical developed Querco – Piceetum herb layer. The transition from one association to another took place on a very small area (4 m) as compared with transect length and the area occupied by phytocoenoses examined. Thus the border was sharp and distinct. New, significant species of herb layer plants did not appear and indices of intraspecific relations, such as relative value, representativeness and Czekanowski's diagram did not indicate any kind of third association between those examined.

The studies on changes of habitat conditions along the transect, out of necessity limited to soil analysis, showed in some cases the correlation of some soil properties and changes in spatial structure of herb layer of both associations and the contact zone between them. On the first squares of the transect with association Peucedano – Pinetum there was proper podsolic soil formed of coarse sandy soil (Fig. 7). The ground water level was at 90–70 cm and increased with the distance from the beginning of the transect, and thus in squares 12–16 the ground water occurred at about 60 cm. In this zone the proper podsolic soil changed gradually into mucky podsolic soil, raw

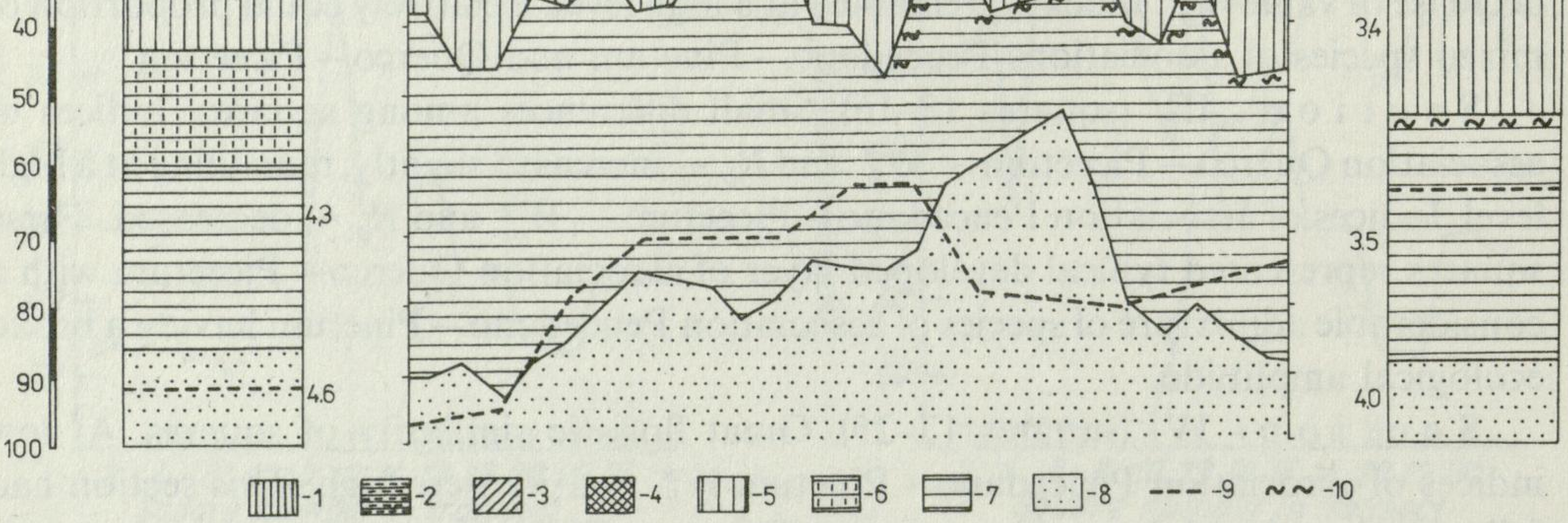

Fig. 7. Schematic diagrams of soil profiles on the surface of records and soil variability on the transect 1 – litter layer A_L, 2 – raw humus sub-horizon A_{FH}, 3 – humus horizon A_1, 4 – horizon of accumulation of mucky humus A_1M, 5 – eluvial horizon A_2, 6 – iluvial horizon with iron accumulation B_{Fe}, 7 – iluvial horizon B, 8 – parent rock C, 9 – ground water level, 10 – ground gley horizon G

humus sub-horizon thickened and the horizon of accumulation of mucky humus appeared. The moisture increased in the whole profile and the bottom genetic horizons showed gleying marks. Conditions were similar in further squares of the transect.

The results of analyses of soil samples from the transect show that almost all parameters change greatly and stepwise in the space. Significant differences are only in the case of soil abundance in the raw humus sub-horizon A_{FH} in potassium, phosphorus, iron and ammonium nitrogen (Fig. 8). Despite considerable fluctuations of these parameters in successive squares the contents of above-mentioned compounds increase with the distance from phytocoenosis of association Peucedano – Pinetum

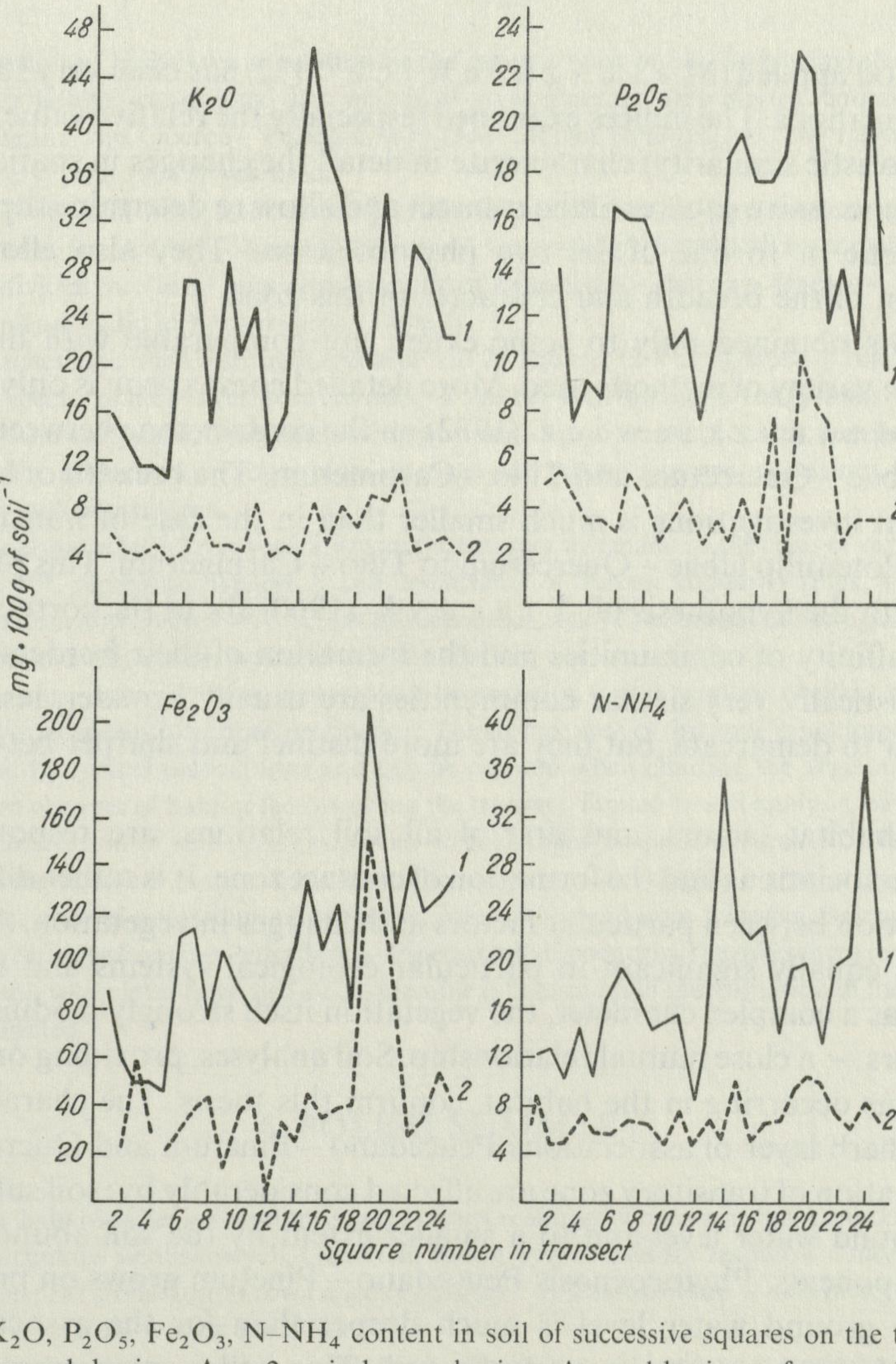

Fig. 8. K_2O, P_2O_5, Fe_2O_3, N–NH_4 content in soil of successive squares on the transect
1 – in raw humus sub-horizon A_{FH}, 2 – in humus horizon A_1, and horizon of accumulation of mucky humus A_1M

towards association Querco – Piceetum. Despite the relatively continuous gradient of changes of these factors the transitory zone between associations examined is a sharp and distinct boundary.

There is no distinct correlation between the changes in spatial structure of herb layer and the soil abundance in sodium, calcium and nitrate nitrogen. The humus content, organic matter content, soil acidity are relatively stable along the transect. An analysis of magnesium and calcium carbonate content have showed that they occur in trace amounts.

4. DISCUSSION

The method applied (M a t u s z k i e w i c z 1972) has been very suitable for this type of investigations. The indices examined (especially the relative value, representativeness and floristic similarity) characterize in detail the changes in spatial structure of herb layer in successive squares of the transect and allow to determine their attachment to contact zone or to one of the two phytocoenoses. They also allow for precise determination of the breadth and character of this zone.

The results obtained only to some extent are comparable with literature data, because of the variety of methods used. More detailed comparison is only possible with the data of M a t u s z k i e w i c z (1972) on the contact zone between associations Potentillo albae – Quercetum and Tilio – Carpinetum. The breadth of borders observed in present investigations is much smaller than in the case of transition from the community Potentillo albae – Quercetum to Tilio – Carpinetum. This phenomenon is consistent with the hypothesis of T r a c z y k (1960) about the correlation between the floristic affinity of communities and the formation of their borders. The borders between floristically very similar communities are usually broader, less distinct and more difficult to demarcate, but they are more distinct and sharper between separate associations.

Various habitat factors, and first of all soil relations, are responsible for the structure of associations and the formation of contact zone. It is rather difficult to find a close correlation between particular factors and changes in vegetation. Although each factor is not equally significant in particular ecological systems and their effect on vegetation has a complex character, the vegetation itself strongly modifies the effect of habitat factors – a close mutual relationship. Soil analyses, providing only a fragment of all relations occurring in the habitat, confirm this thesis. The character of spatial structure of herb layer of associations Peucedano – Pinetum and Querco – Piceetum and the formation of transitory zone are affected considerably by: soil sub-type and the depth of ground water level and to a smaller extent by the soil abundance in some mineral components. Phytocoenosis Peucedano – Pinetum grows on proper podsolic soil and the ground water level is much deeper than for the association Querco – Piceetum formed on mucky podsolic soil. This soil is also more abundant in potassium, phosphorus, iron and ammonium nitrogen than the soil of association

Peucedano – Pinetum. Results of soil analyses are similar to those obtained by Izdebski and Popiołek (1975), Izdebski et al. (1976), Izdebski, Kimsa and Stączek (1976), who have conducted investigations on similar associations of central Roztocze region.

The method used also has some deficiencies. It does not take into consideration the whole spatial structure of herb layer, and especially the degree of covering by individuals from particular species. A modification, where this factor would be used in statistical calculations, would characterize better the contact zone.

5. SUMMARY

Spatial structure of herb layer vegetation in the contact zone of two forest phytocoenoses has been described against habitat conditions. The object of investigations were phytocoenoses of associations Peucedano – Pinetum and Querco – Piceetum and their contact zone (Fig. 1). The method suggested by Matuszkiewicz (1972) was used.

On typical patches of both associations phytosociological records were made using the method of Greig-Smith's square (square 16 × 16 m divided into 64 squares). Species of herb layer plants on the surface of records were divided into local ones characteristic of Peucedano – Pinetum, Querco – Piceetum, and of equal number and sporadic in both records (Table I).

Between patches examined a straight transect had 25 squares (2 × 2 m), close to one another. In each square the plant species of herb layer were recorded. Together with floristic investigations soil pits were dug and soil samples were analysed for: mechanical composition, organic matter content, humus content, $CaCO_3$ content, soil acidity, abundance in ammonium nitrogen and nitrate nitrogen, potassium, sodium, calcium, magnesium, iron and phosphorus.

Statistical analysis of herb layer vegetation on the transect was made on the basis of variability of indices of relative value W^*, representativeness R and coefficients of floristic similarity (Figs. 4–6). Associations Peucedano – Pinetum and Querco – Piceetum had a contact zone (12 m broad), covering also the transitory zone (4 m broad), and this border was a sharp and distinct one.

The contact zone does not have a new plant community, it is a mixture of plant species from two neighbouring phytocoenoses in various proportion. The surface area of this zone is not important in relation to areas occupied by typical associations and can be omitted when charting the vegetation.

The studies on changes of habitat factors along the transect, limited to soil analysis, have shown only in some cases the correlation of some soil properties with changes in spatial structure of herb layer of both associations and the existence of transitory zone. The soil parameters display a great stepwise variability in space. Only in the case of potassium, phosphorus, iron and ammonium nitrogen their amounts increase together with the distance from the Peucedano – Pinetum phytocoenosis. The differences in soil sub-type and the depth of ground water level have also a considerable influence upon the formation of the border between associations examined.

6. POLISH SUMMARY

Celem pracy było określenie struktury przestrzennej roślinności runa w strefie kontaktowej 2 fitocenoz leśnych na tle warunków siedliskowych. Obiektem badań były fitocenozy zespołów *Peucedano – Pinetum* i *Querco – Piceetum* oraz strefa kontaktowa między nimi (rys. 1). Zastosowano w nich metodę zaproponowaną przez Matuszkiewicza (1972).

W typowych płatach obu zespołów wykonano zdjęcia fitosocjologiczne metodą kraty Greig-Smitha (kwadrat o boku 16 m podzielony wewnątrz na 64 mniejsze kwadraty). Występujące na powierzchniach

zdjęć gatunki roślin runa podzielono na lokalnie wyróżniające bór świeży, bór mieszany oraz równoliczne i sporadyczne w obu zdjęciach (tab. I).

Pomiędzy badanymi płatami obydwóch asocjacji wytyczono w prostej linii transekt składający się z 25 kwadratów o boku 2 m ściśle przylegających do siebie. W każdym kwadracie notowane były występujące gatunki roślin runa. Jednocześnie z badaniami florystycznymi kopano odkrywki glebowe i pobierano próbki do analizy. Określano w nich: skład mechaniczny, zawartość substancji organicznej, zawartość próchnicy, ilość $CaCO_3$, odczyn gleby, zasobność w azot amonowy i azotanowy, potas, sód, wapń, magnez, żelazo i fosfor.

Analizę statystyczną roślinności runa na transekcie przeprowadzono na podstawie przebiegu zmienności wskaźników waloru względnego W^*, reprezentatywności R i współczynników podobieństwa florystycznego (rys. 4–6). Stwierdzono istnienie między zespołami *Peucedano – Pinetum* i *Querco – Piceetum* strefy kontaktowej (szerokości 12 m), a w jej obrębie strefy przejścia o szerokości 4 m, mającej charakter ostrej i wyraźnej granicy.

W strefie kontaktowej nie wytwarza się nowe zbiorowisko roślinne, następuje tam jedynie wymieszanie się gatunków roślin występujących w sąsiednich fitocenozach, w różnym stosunku ilościowym. Powierzchnia tej strefy jest w zasadzie nieistotna w odniesieniu do obszarów zajmowanych przez typowe zespoły i przy kartowaniu roślinności może być pominięta.

Badania zmian czynników siedliskowych na długości transektu, ograniczone do analizy gleb, wykazały tylko w niektórych przypadkach istnienie korelacji pewnych właściwości gleb ze zmianami w strukturze przestrzennej runa obydwóch zespołów i strefy przejścia między nimi. Wartości badanych parametrów glebowych wykazały bardzo dużą skokową zmienność w przestrzeni. Jedynie w przypadku zawartości potasu, fosforu, żelaza i azotu amonowego zaznaczył się wyraźny wzrost ich ilości w miarę oddalania się od fitocenozy *Peucedano – Pinetum.* Znaczny wpływ na kształtowanie się granicy między badanymi zespołami mają również różnice w podtypie gleby oraz głębokości zalegania wody gruntowej (rys. 7, 8).

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