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THE SOIL AND FOREST VEGETATION RELATIONSHIP IN THE LIGHT OF THE ANALYSIS OF SOME PROPERTIES OF BROWN SOIL OVER LIMESTONE IN THE KARST REGION OF WESTERN CROATIA

ODNOS TLA I ŠUMSKE VEGETACIJE U SVJETLU RAŠČLAMBE NEKIH SVOJSTAVA SMEĐEGA TLA NA VAPNENCU NA KRŠU ZAPADNE HRVATSKE

NIKOLA PERNAR

Department of silviculture, Faculty of forestry, University of Zagreb,
Svetošimunska 25, HR-10000 Zagreb

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In this work the impact of vegetation on the properties of brown soil over limestone in the karst region of western Croatia has been investigated. The investigation was carried out in five dominant climazonal communities. The results suggest significant differences for some properties of brown soil over limestone (the parameters explaining relatively well the soil organic matter status) between individual forest associations. In addition, littoral the forest associations are very well discriminated from the continental ones. The specific influence of a plant species (although this was not the objective of the investigations) is recognisable in the forest associations with pure beech stands which can be attributed primarily to the influence of litter (plant tissue). The discriminating analysis proved to be very suitable for the determination of the impact of vegetation on the organic complex properties in brown soil over limestone. By including a larger number of pedophysiographical parameters, and using the discriminating analysis, their connection with vegetation characteristics could be explained in an even better way.

Key words: brown soil over limestone, soil organic matter, humus, vegetation, karst

INTRODUCTION
UVOD

The high karst of western Croatia - Gorski kotar with the massifs of Velebit and Kapela is the most valuable woodland in Croatia from the economical, social and conservation aspect. Nevertheless, when speaking of soils over karst in Croatia, including the soils in the said region, the final replies to numerous open questions, such as the origin of mineral particles, formation time and conditions, geochemical characteristics, geographical regularities, etc. have not yet been given.

For the karst region of Croatia, the relations between the soils in terms of their vertical distribution are known (Gračanin 1972, Mayer 1992). In this distribution, brown soil over limestone can be said to have the widest elevational amplitude in the western Croatian pedosphere. Bertović (1971) described in detail the relationship between the soils and the vegetation around Zavižan on northern Velebit. This description clearly indicates that brown soil over limestone is predominant in all plant communities except in the mugho pine association.

According to Martinović (1990), brown soil over limestone is the most frequent soil by far in the Croatian pedosphere, with a surface area of 9,243 km^2 or 17.55% of the pedosphere surface. Preliminary investigations have proved that its share in the western Croatia karst pedosphere is generally higher still. Consequently, when speaking of the variability and heterogeneity of the pedosphere over karst, it should be noted that brown soil over limestone is the largest participant in this variability, so it is logical that it is taken as sample to study this issue.

According to Živanov (1962), the humus accumulation horizon, primarily the organic complex parameters, reflect best the natural variability of soil parameters which can be conditioned by a number of factors. The most important of these factors are, when the same soil type is concerned, tree species, height above sea level and relief.

The heterogeneity of soils over karst proved to be very high owing to the parent substrate properties (Vranković 1971). According to Taboada et al. (1995), a very marked pedosphere heterogeneity is mainly found on limestone.

There are several reasons for this, including:

- the strata position, wearing and water permeability, a very heterogeneous parent substrate;
- uneven pedosphere thickness;
- ground relief, and consequently macroclimatic differences;
- plant species variability;
- pedofauna variability, including that of microflora and microfauna
- wind impact, etc;

Considering the fact that the largest part of Croatia, which in terms of morphology and hydrogeology is called karst, is abundant in forests and forest soils developed on Mesozoic dolomite rocks, the importance of the issue concerning the real causes of the variability of pedophysiological properties becomes evident. Gračanin (1931) writes that the forest "wherever it occurs is an important pedological factor but hardly anywhere is its importance so decisive for soil development as on our karst."

As far as soils over limestone are concerned, it should be borne in mind that the size of the elementary soil range (Fridland 1984), the pedon, is very variable and that most often it is directly connected with the internal parent material relief.

In addition, the parent material, typical of this region, especially in its northern part (Velebit - Gorski kotar), is the sharpest climatic boundary in this part of Europe. Here, the Mediterranean climate suddenly changes into the cold continental climate type, followed by a marked vegetation change. So, the influence of the vegetation factor on the organic matter and the topsoil takes the form here of a pronounced phytobioclimatic influence. Consequently, in this area, which can be designated as the northern region of Croatian karst or the karst region western Croatia, there are, due to the climatic influence, distinct elevational vegetation zones with typical climazonal communities (Horvat 1962, Pelcer & Martinović 1990, Rauš et al. 1992, Trinajstić 1970). According to Stevenson (1994), the climate is the most important individual factor affecting the spatial distribution of plant species, the amount of produced plant matter and the intensity of soil microbiological acitivity - which means that this factor has a decisive role in the soil organic matter accumulation and transformation.

In addition to the recent, direct and indirect (through the spatial distribution of vegetation) climate influence on soil properties, the relict climatic influence in this region also can be considered. Thus, some soil properties in this part of the karst region can be explained as the consequence of specific Pleistocene climatic changes (Stritar et al. 1967).

On the basis of the extensive research carried out by Jenny (1930, 1941, 1958) in wide areas of the eastern part of the U.S., the scientific problem of the relationship of climate, soil and vegetation can be presented in the form of a triangle

$$\begin{tikzcd} & \text{CLIMATE} \arrow[dl] \arrow[dr] & \\ \text{VEGETATION} \arrow[rr, shift right] & & \text{SOIL} \arrow[ll, shift right] \end{tikzcd}$$

which can be interpreted briefly in the following way:

1. The climate affects directly both the vegetation and the soil, so each relationship between the soil and the vegetation also includes in itself the climatic influence.

2. The soil and the vegetation interact in two directions, this relationship being controlled by the climatic influence.

3. Under the same climatic and pedogenetic conditions, the same vegetation is developed.

Wraber (1967) thinks that "the vegetation development rate as well as the soil development generally are affected by the same environmental factors - climate, ground relief, geological composition and ground hydrology - the biotic factors, but there are qualitative and quantitative differences as to the way in which these factors affect the vegetation or the soil. The vegetation also has quite a strong influence on the soil substrate which, from its part affects the vegetation, but this reciprocal action is not of equal intensity in both directions. Plant associations and the soil are developed parallelly and interdependently. For this reason between both these systems causal relationships exist, although most often the cause and the effect cannot be distinguished."

The forest vegetation affects the soil through the litter, roots and climate modifications (Kundler 1963), the most direct influence being through the litter (Jović 1969, Koegel et al. 1988).

The nitrogen and carbon concentration variability in the surface horizon in the Cascade Mountains in Oregon proved to be attributable to the vegetation influence (McNabb et al. 1986).

Using the regression analysis for 134 forest pedons, Homann et al. (1995) proved that stand characteristics explain 50% of the soil organic carbon variability.

Speaking of the influence of the forest on the soil, Zonn (1960) also mentions the specific influence of individual tree species on the soil organic matter quantity and character.

According to what is known about the geochemical role of forest trees, a different influence on soil evolution, and consequently on its physiography and on its trophicity is to be expected in different climatic conditions and where there is a different proportion of individual species.

The quality of information on forest soil and its involment in forest management or spatial planning for a certain region depends primarily on the variability of forest soil physiographical properties, especially those in the topsoil.

This surface layer of the soil is its most dynamic sphere, where most energy enters and leaves the system. When physiological functions end, and after reaching the soil, or the solum itself, the plant and animal tissue is included into a non-return substance transformation cycle in nature. Organic tissue continuously comes onto and into the soil where it is not only transformed but translocated (Kumada 1987). A large part of the reaction products leaves the soil. Research concerning the organic matter accumulation rate has shown that it is stabilised between 110 (on fine texture material) and 1500 years (on carse texture material) (Stevenson 1994).

Hayes & Swift (1978) consider humus synthesis and degradation as a dynamic process which achieves its balance under specific soil conditions. The soil organic matter is transformed much more quickly than the soil mineral particles, and besides, it is much more variable spatially.

Although many positive characteristics of soil organic matter have been studied thoroughly, it has to be remembered that the soil is a dynamically balanced multicomponent system, so soil characteristics are presented as the effect of various interactions which cannot be attributed solely to the organic matter.

The starting point in this work was a relatively high variability of physiographical properties of the brown soil over limestone, and the objective of the work was to analyse the connection between this variability and the vegetation. For this purpose, factors were selected which directly or indirectly supply information about the soil organic matter status. The task was to investigate, on the basis of the chosen soil and ecosystem status indicators, the regularities in the assumed relationships.

These indicators are as follows:

a) climazonal belongin of vegetation;
b) pedogenetic horizon thickness and soil depth;
c) A-and (B)- soil horizon reaction;
d) humus content in the soil A- and (B)- horizons;
e) total and mineral nitrogen contents in the soil A- and (B)-horizons;
f) physiologically active phosphorus and potassium content in the soil A- and (B)- horizons;
g) clay content in the soil A- and (B)- horizons.

In performing this task, special attention is given to the parameters which best explain the qualitative and quantitative properties of soil organic matter, namely to the humus and nitrogen content, which in this respect can be designated as "thematic variables".

The humus content is the main parameter of soil organic matter. The total nitrogen status is closely connected with the soil humus status because humus matters are high-molecular compounds with 1-5% of total nitrogen in their chemical composition and also because most nitrogen in forest soils is incorporated in these matters.

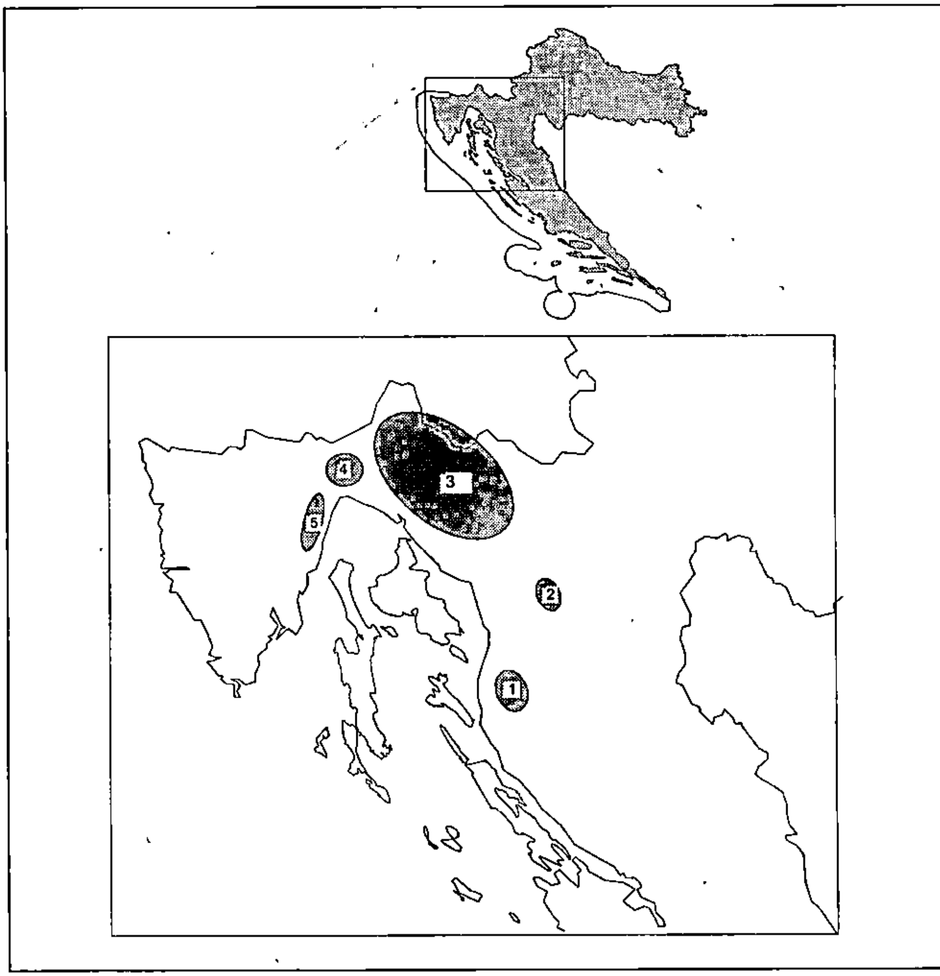
The content and shapes of soil nitrogen mineral forms are an extremely dynamic geochemical phenomenon affected by many factors. However, as it appeared to be a very sensitive indicator of forest ecosystem status, it presents an interesting parameter in the analysis of the soil organic complex status and its variability.

REGION OF INVESTIGATION AND METHODS
PODRUČJE ISTRAŽIVANJA I METODE

The region of investigation has been divided into 5 subregions (Fig. 1):

1. Northern Velebit
2. Velika Kapela
3. Gorski kotar
4. Rijeka and Opatija hinterland
5. Učka

Figure 1. Investigated area geographic position chart
Slika 1. Položaj istraživanog područja



According to Thorntwait's classification, subregions 1, 2, 3 and 5 have a perhumid climate (P/E127) and subregion 4 a humid climate (P/E=64-127). The climate characteristics are more contrasting than this statement implies, as can be seen from the review of the dominant climazonal forest associations:

1. *Ostryo-Quercetum pubescentis* /Ht./ Trinajstić 1977 (OST-QUE.)
   - mixed pubescent oak and hop hornbeam forests - subregion 4
2. *Seslerio-Fagetum sylvaticae* /Ht.1950/ M.Wraber 1960 (SES-FAG.)
   - beech and sesleria forest - subregions 3, 4 and 5
3. *Abieti-Fagetum dinaricum* Treg. 1957 (ABI-FAG.)
   - Dinaric beech-fir forests - subregions 1 and 3

4. *Homogino alpinae-Fagetum sylvaticae* /Ht.1938/ Borh.1963(HOM-FAG.)
   - sub-Alpine beech forest with homogyne - subregions 1and 3
5. *Lamio orvale-Fagetum sylvaticae* Ht. 1938 (LAM-FAG.)
   - mountain beech forest with dead nettle - subregion 2.

The geological structure of the described region consists mostly of limestone and dolomite of the Mesozoic age, with Jurassic-formation limestone dominating. In addition to these Mesozoic formations, a wider region of investigation also comprises others formations, younger or older (Herak 1960), but they are not included in the present investigation.

From both the geological and the morphological standpoint, the region of investigation belongs to the karst of the northwestern Dinaric Alps. The entire region of investigation owes its outer aspect primarily to the geotechtonical motions that occurred during its geological past, followed by the action of external factors in the form of the effects of water erosion (especially in the areas of high faults and folds), namely of glacial ice in the Pleistocene epoch (some parts of Gorski kotar and Velebit).

With regard to the type of geological-lythological stratum in the investigated region, the soils generally belong to the developement series of soils on pure, compact limestone. Such substrate with 0.2-2% of insoluble residue, is generally common for these soils, which marks strongly their genesis and properties. This area includes rocky ground, black soil, brown soil over limestone and illimerized soils. In the pedosphere, brown soil over limestone, occurs more frequently.

In the selection of control objects, namely forest stands in which field measurements and soil sampling were made, the following criteria were taken into consideration:

1. To exclude the influence of parent substrate.

2. In the respective areas, the vegetation relationships were studied from the aspect of their belonging to climazonal plant communities, typical for this part of Croatia. Five plant communities with complete ranges were chosen, which in their greatest part coincide with the range of Jurassic and Createceous limestone, and with pronounced elevational zones.

3. On the basis of the pedological-cartographic documentation, in this region ranges with the dominant presence of brown soil over limestone in the pedosphere were separated.

4. From this three-layer system, potential areas and localities were chosen in which the investigations were continued.

On the basis of knowledge concerning the variability of pedological parameters and the determination of a minimum sample size (Cline 1944, Christensen & Malmoros 1984, Starr et al. 1995, Živanov 1962), the following requirements in determining the position of pedological profiles and the composition of average soil samples for laboratory analysis were fixed:

a) the geological-lythological stratum homogeneity based on field observations;

b) quiet microrelief - exclusion of possible excessive pedoturbation caused anthropogenetically or by natural processes;
c) exclusion extreme positions of mezzorelief - peaks and downs;
d) stand canopy completeness;
e) sampling away from roots - in the outer third of dominant tree crown projection;
f) the endomorphology characteristic of medium deep, typical brown soil over limestone.

Individual samples were taken in genetical (A- and (B)rz-) horizons on the main profile dug in the outer third of the tree crown projection of the dominant tree in the stand and on another three auxiliary profiles dug under the same conditions inside the elementary soil range. Attention was paid to the fact that when soils over limestone are involved, the elementary soil range size, the polypedon (Fridland 1984), varies significantly and that most often it is directly connected with the parent material internal relief which is closely connected with the rock character. On the main profile, three samples were taken (one from the profile front and one from each of the lateral sides), from which, together with the samples from auxiliary profiles (in total, six individual samples), an average sample was made, separately for the A- and (B)rz- horizons. Sampling was made on 155 locations, distributed as follows:

OST-QUE. - 17
SES-FAG. - 26
ABI-FAG. - 47
HOM-FAG. - 40
LAM-FAG. - 25

The soil laboratory analyses were made using the following methods:

1. Soil reaction - electrometrically, with combined electrode, using soil suspension in water, namely in 0.01 M$CaCl_2$, in a ratio of 1:2.5;

2. Humus content - using the bichromate method according to Tjurin;

3. Total nitrogen content - burning according to Kjeldahl's procedure and distillation according to Bremner;

4. Nitrate nitrogen content - by spectrophotometry (436) after extraction in 0.2 M K_2SO_4 and coloration with phenoldisulphonic acid;

5. Ammonia nitrogen content - by spectrophotometry (436 mm) after extraction in 0.2 M K_2SO_4 and coloration with Nesler reagent;

6. Content of physiologically active forms of potassium and phosphorus - using the AL method;

7. Mechanical soil composition - by pipette method after deaggregate in 0.2 M $Na_4P_2O_7$.

All other pedological parameters used in further analyses were determined mathematically.

Separation of forest associations in the area of measured pedological variables (to evaluate the contribution of various phytobioclimates to the variability of the brown soil over limestone organic complex), as well as in the area of geomorphological variables (to evaluate the frequency of the geomorphological variable influence on the pedological variability through the forest associations themselves), was tested using the discriminating analysis (Mardia et al. 1982). Discrimination according to all pedological variables, as well as according to thematic variables A-, namely (B)rz- horizons (humus content, total nitrogen content and mineral nitrogen content) was made. The results presented here are given by means of: a classification matrix, a table of standardised linear coefficients for each inlet variable in each discriminatory variable (contributions of measured variables to their linear combination maximising group separation), and a dispersion diagram for classified profiles in the discriminant subarea. The canonical correlation was applied once more in linking up two sets of discriminatory variables (pedological and geomorphological discrimination criteria) to evaluate the indirect contribution of geomorphological variables in the discrimination of forest associations according to the measured pedological variables. The statistical analyses were made in the CSS-Statistica 4.3 program package.

LIST OF SYMBOLS AND ABBREVIATIONS
POPIS SIMBOLA I SKRAĆENICA

A_C - organic carbon content in A- horizon

A_C:N - relationship of content of organic carbon and total nitrogen in A- horizon

A_C_H_2SO_4 - content of organic carbon in A- horizon, extracted with 0.05 M H_2SO_4

A_C_ost - nonextracted organic carbon in A- horizon (with mixture of 0.1 M $Na_4P_2O_7 \times 10\ H_20$ and 0.1 M NaOH)

A_dub - depth of A- horizon

A_gli - clay content in A- horizon

A_hum - humus content in A- horizon

A_K_2O - physiologically active potassium content in A-horizon

A_N_m - mineral nitrogen content in A-horizon

A_N_m:N_uk - relationship between mineral and total nitrogen content in A-horizon

A_N_NH_4 - ammonia nitrogen content in A-horizon

A_N_NH_4:N_uk - relationship between ammonia and total nitrogen content in A-horizon

A_N_NO_3 - nitrate nitrogen content in A-horizon

A_N_NO_3:N_uk - relationship between nitrate and total nitrogen content in A-horizon

A_N_uk - total nitrogen content in A-horizon

A_P_2O_5 - physiologically active phosphorus content in A-horizon
A_pH_$CaCl_2$ - pH- value in A- horizon - measured in 0.01 M $CaCl_2$
A_pH_H_2O - pH- value in A- horizon - measured in water
ABI-FAG. (ABI-FAG.), (3) - *Abiet-Fagetum dinaricum* Treg. 1957
(B)_C:N - relationship of content of organic carbon and total nitrogen in (B)rz- horizon
(B)_dub - depth of (B)rz- horizon
(B)_gli - clay content in A- horizon (B)rz- horizon
(B)_hum - humus content in (B)rz- horizon
(B)_K_2O - physiologically active potassium content in (B)rz-horizon
(B)_N_m - mineral nitrogen content in (B)rz- horizon
(B)_N_m:N_uk - relationship between mineral and total nitrogen content in (B)rz- horizon
(B)_N_NH_4 - ammonia nitrogen content in (B)rz- horizon
(B)_N_NH_4:N_uk - relationship between ammonia and total nitrogen content in (B)rz- horizon
(B)_N_NO_3 - total nitrogen content in (B)rz- horizon
(B)_N_NO_3:N_uk - relationship between nitrate and total nitrogen content in (B)rz- horizon
(B)_N_uk - total nitrogen content in (B)rz- horizon
(B)_P_2O_5 - physiologically active phosphorus content in (B)rz- horizon
(B)_pH_$CaCl_2$ - pH- value in (B)rz- horizon - measured in 0.01 M
(B)_pH_H_2O - pH- value in (B)rz- horizon - measured in water
HOM-FAG. (HOM-FAG.), (4) - *Homogino alpinae-Fagetum sylvaticae* /Ht. 1938/Borh. 1963
LAM-FAG. (LAM-FAG.), (5) - *Lamio orvale-Fagetum sylvaticae* Ht. 1938
OKT - soil organic complex
OST-QUE. (OST-QUE.), (1) - *Ostryo-Quercetum pubescentis* /Ht./ Trinajstić 1977
OTT - soil organic matter
SES-FAG. (SES-FAG.), (2) - *Seslerio-Fagetum sylvaticae* /Ht. 1950/ M. Wraber 1960

INVESTIGATION RESULTS
REZULTATI ISTRAŽIVANJA

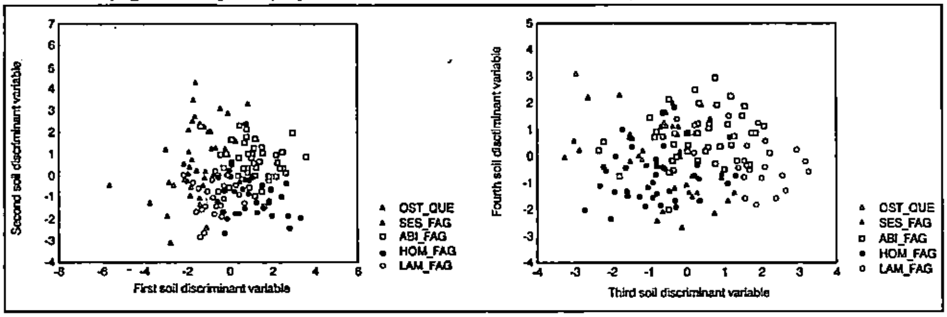
To evaluate the influence of vegetation on the organic complex variability of brown soil over limestone, the most suitable method, due to the vegetation data quality, is the forest associations discriminating analysis according to the measured pedological variables.

Forest associations discrimination based on the pedological variables is very high - 81.9% of properly classified pedological profiles (Table 1, Fig. 2), so here, with regard to the organic complex, the forest associations can be interpreted largely as separate pedological units. The continental forest associations were discriminated from the Mediterranean ones according to the measured pedological variables to an even larger extent than the individual ones, as can be seen from the classification matrix as well as in the dispersion diagram where the OST-QUE. is mixed only with the SES-FAG., while the ABI-FAG., HOM-FAG. and LAM-FAG are mixed only to a lesser extent with the Mediterranean forest associations. The additional influence of various macroclimate types, and consequently of different vegetation zone types, is evident, which obviously has an influence on pedogenesis.

Table 1. Classification matrix of forest associations according to soil variables
Tablica 1. Klasifikacijska matrica biljnih zajednica prema pedološkim varijablama

Forest associations *Biljne zajednice*	Correct *Ispravno* (%)	1:1 p=0.110	2:2 p=0.168	3:3 p=0.303	4:4 p=0.258	5:5 p=0.161
1	2	3	4	5	6	7
Ostryo-Quercetum	94.12	16	1	0	0	0
Seslerio-Fagetum	73.08	5	19	1	1	0
Abieti-Fagetum	78.72	0	1	37	5	4
Homogino-Fagetum	82.50	1	1	5	33	0
Lamio-Fagetum	88.00	1	0	1	1	22
Total - *Ukupno*	81.94	23	22	44	40	26

Figure 2. Scatterplot of soil discriminant variables
Slika 2. Dijagram raspršenja pedoloških diskriminatornih varijabli



Contributions of individual measured pedological variables to the discriminatory variables are shown in Table 2, where, from the cumulatively expressed relative property values, it is visible that not one discriminatory variable can be neglected. The specific litter influence of dominant species in the stand can be conjectured on the fourth discriminatory variable (Fig. 2), according to which the pure beech stands are not distinguished regardless of the climate (SES.-FAG., HOM.-FAG. and LAM.-FAG.), while the ABI-FAG. and OST-QUE are separated, and the macroclimates on the first discriminatory variable (Fig. 2). Presently, it can only be assumed that other discriminatory variables might present influences of ground plant cover, biomass, topoclimate, etc.

Table 2. Standardised coefficients for soil discriminant variables
Tablica 2. Standardizirani koeficijenti za pedološke diskriminatorne varijable

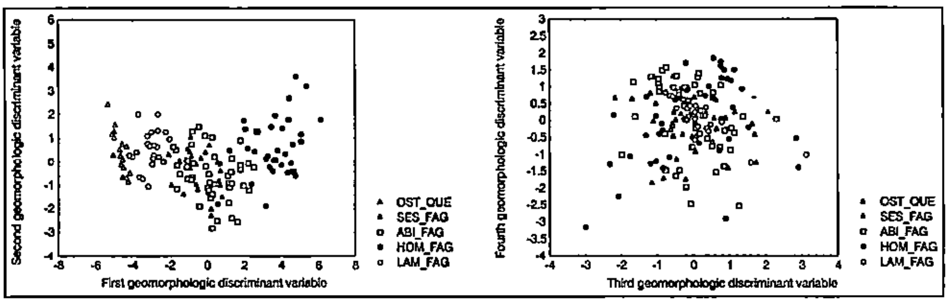
Variable *Varijabla*		Standardized coefficients for discriminant variables *Standardizirani koeficijenti za diskriminatorne varijable*			
		First variable *Prva varijabla*	Second variable *Druga varijabla*	Third variable *Treća varijabla*	Fourth variable *Četvrta varijabla*
1		2	3	4	5
A_dub		0.1754	0.5341	0.4097	-0.5519
A_pH_H_2O		-0.1782	-0.0368	0.0636	0.4574
A_hum		0.2813	1.3083	0.1790	1.2868
A_N_NO_3		-0.8247	-0.6337	-0.4570	-0.3800
A_N_NH_4		-0.0219	-1.4726	1.0724	-2.1440
A_N_NO_3:N_uk		0.5520	0.4423	0.4818	0.6529
A_N_NH_4:N_uk		0.1388	1.2441	-0.8287	1.7468
A_C:N		0.3003	-1.1235	-0.0028	-1.5710
A_P_2O_5		-0.0739	0.1190	0.1496	-0.0210
A_K_2O		-0.5187	0.2368	-0.2549	0.0592
A_gli		0.0871	0.0491	-0.4853	-0.0548
(B)_dub		-0.4839	0.2860	-0.3378	0.1236
(B)_pH_H_2O		0.2242	0.0080	0.0259	-0.0524
(B)_hum		-0.5391	1.1313	-0.9203	-0.2239
(B)_N_NO_3		0.8735	0.1896	0.0383	0.4112
(B)_N_NH_4		-0.4961	-1.2186	0.6091	0.3374
(B)_N_NO_3:N_uk		-0.3646	-0.2386	-0.2347	-0.5857
(B)_N_NH_4:N_uk		0.5563	1.0829	-0.5447	-0.0740
(B)_C:N		0.4354	-0.6078	0.4254	0.5975
(B)_P_2O_5		-0.2928	0.0301	0.0339	-0.3346
(B)_K_2O		-0.2639	-0.4535	-0.2515	0.0218
(B)_gli		0.1581	-0.0469	-0.2262	-0.1601
Eigenvalues *Svojstvene vrijednosti*	Single *Pojedinačno*	1.3945	0.9489	0.8853	0.5094
	Cumulative *Kumulativno*	0.3730	0.6269	0.8637	1.0000

Nevertheless, the forest associations discrimination based on the geomorphological variables is also very high - 80.6% of properly classified pedological profiles (Table 3, Fig. 3). Here, the last three discriminatory variables can practically be neglected, mostly due to the dominant influence of height above sea level, but also due to higher or lower contributions and other geomorphological variables to the first discriminatory variable (Table 4). As the total amount of shares of properly classified pedological profiles from the two described discriminating analyses considerably exceed 100%, this means that the forest associations discrimination, according to the pedological variables, as an attempt to estimate indirectly the impact of vegetation on the organic complex, also included the previously tested and proven independent evaluation factors. Accordingly, the canonical correlation of two discriminatory variable sets from two discriminating analyses is R=0.686, while other results (Table 5 and 6, Fig. 4 and 5) underline again the dominant influence of height above sea level.

Table 3. Classification matrix of forest associations according to geomorphological variables
Tablica 3. Klasifikacijska matrica biljnih zajednica prema geomorfološkim varijablama

Forest associations *Biljne zajednice*	Correct *Ispravno* (%)	1:1 p=0.110	2:2 p=0.168	3:3 p=0.303	4:4 p=0.258	5:5 p=0.161
1	2	3	4	5	6	7
Ostryo-Quercetum	100.00	17	0	0	0	0
Seslerio-Fagetum	46.15	0	12	13	0	1
Abieti-Fagetum	72.34	0	8	34	3	2
Homogino-Fagetum	95.00	0	0	2	38	0
Lamio-Fagetum	96.00	1	0	0	0	24
Total - *Ukupno*	80.65	18	20	49	41	27

Figure 3. Scatterplot of geomorphologic discriminant variables
Slika 3. Dijagram raspršenja geomorfoloških diskriminatornih varijabli



If only the thematic[1] pedological variables are taken in the discriminating analysis, the percentage of properly classified pedological profiles is lower (Table 7); in total 57.4% of properly classified profiles. This leads to the conclusion that

[1] A_hum, A_N_NO3, A_NH4, (B)_hum, (B)_N_NO3, (B)_NH4

other pedological variables contribute to a lesser extent to the forest associations discrimination; thus, from the classification matrix it can also be seen that the continental forest associations are discriminated from the sub-Mediterranean ones. According to the cumulatively expressed property values (Table 8), it is visible that the third and fourth variables can be neglected; their total contribution to the discrimination is 9%. The first variable shows as high as forest associations discrimination according to the thematic pedological variables with as 65% (Table 8), while from the dispersion diagram (Fig. 6) it can be seen that the forest associations ABI-FAG. and HOM-FAG. are separated from other forest associations. However this is very likely attributable, to the fullest extent, to the macroclimatic and topoclimatic influence, which is directly connected with height above sea level.

Table 4. Standardised coefficients for geomorphological discriminant variables
Tablica 4. Standardizirani koeficijenti za geomorfološke diskriminatorne varijable

Variable *Varijabla*		Standardised coefficients for discriminant variables *Standardizirani koeficijenti za diskriminatorne varijable*			
		First variable *Prva varijabla*	Second variable *Druga varijabla*	Third variable *Treća varijabla*	Fourth variable *Četvrta varijabla*
1		2	3	4	5
Altitude - *Nadmorska visina*		1.0201	-0.0012	0.2221	0.1298
Rockiness - *Stjenovitost*		-0.3518	0.2646	0.6321	-0.2935
Stoniness - *Kamenitost*		0.3398	0.7705	-0.5929	-0.3133
Slope - *Nagib*		0.0273	-0.2956	0.2335	-0.2650
Exposition to sun -*Izloženost suncu*		-0.6149	1.7028	1.0363	0.8046
Orientation - *Orijentacija*		0.4778	-1.6410	-1.2878	-0.2503
Eigenvalues *Svojstvene vrijednosti*	Single *Pojedinačno*	7.9110	0.2461	0.0261	0.0053
	Cumulative *Kumulativno*	0.9661	0.9962	0.9993	1.000

Table 5. Structure of canonical variables for soil variables
Tablica 5. Struktura kanoničkih varijabli za podskup pedoloških varijabli

Variable *Varijabla*	Canonical variables (left set) - *Kanoničke varijable (lijevi set)*			
	First - *Prva*	Second - *Druga*	Third - *Treća*	Fourth - *Četvrta*
1	2	3	4	5
First - *Prva*	0.7401	-0.1168	-0.5287	0.3989
Second - *Druga*	0.0681	-0.9666	0.1873	-0.1612
Third - *Treća*	-0.4139	-0.1532	0.1249	0.8886
Fourth - *Četvrta*	-0.5257	-0.1691	-0.8184	-0.1590

Table 6. Structure of canonical variables for geomorphological variables
Tablica 6. Struktura kanoničkih varijabli za podskup geomorfoloških varijabli

Variable *Varijabla*	Canonical variables (right set) - *Kanoničke varijable (desni set)*			
	First - *Prva*	Second - *Druga*	Third - *Treća*	Fourth - *Četvrta*
1	2	3	4	5
First - *Prva*	0.9964	0.0022	-0.0831	0.0150
Second - *Druga*	0.0105	0.9878	0.1548	0.0137
Third - *Treća*	0.0818	-0.1376	0.9070	-0.3895
Fourth - *Četvrta*	0.0182	-0.0729	0.3828	0.9208

Figure 4. Plot of canonical eigenvalues
Slika 4. Grafikon svojstvenih vrijednosti kanoničkih varijabli.

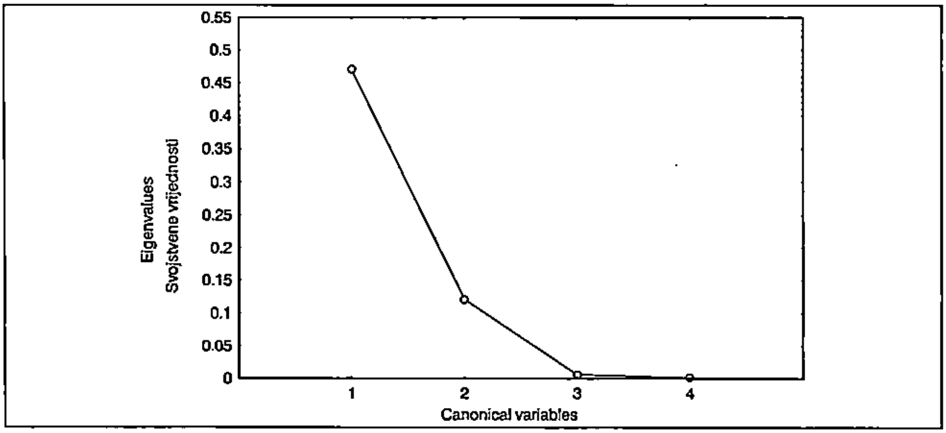


Figure 5. Plot of canonical correlations
Slika 5. Grafikon korelacija kanoničkih varijabli

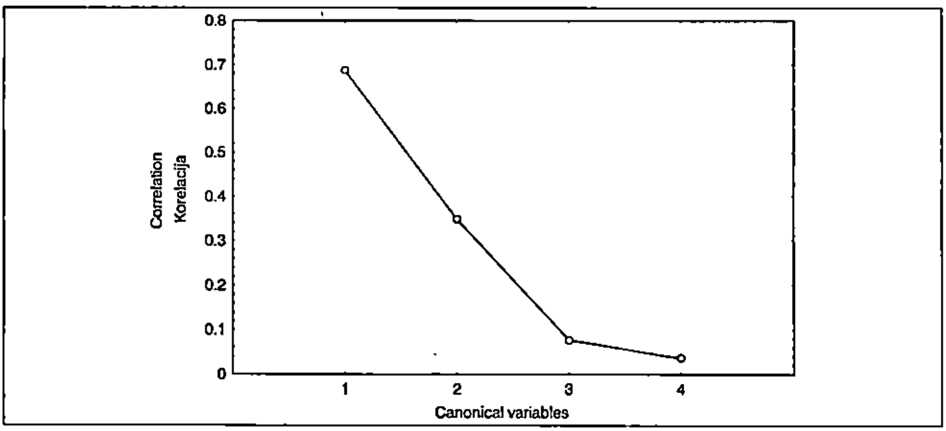


Table 7. Classification matrix of forest associations according to thematic soil variables
Tablica 7. Klasifikacijska matrica biljnih zajednica prema tematskim pedološkim varijablama

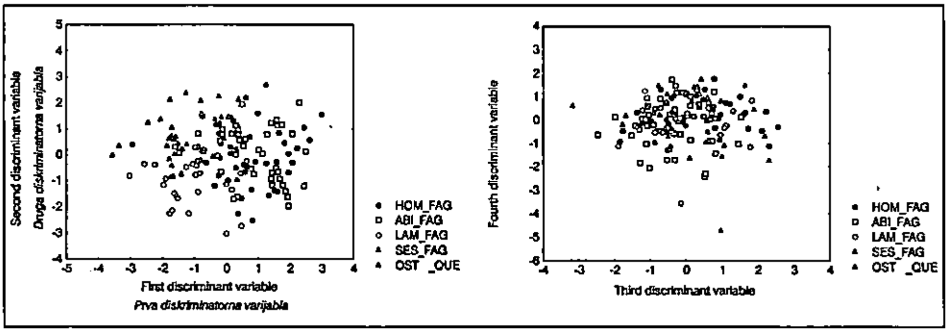
Forest associations *Biljne zajednice*	Correct *Ispravno* (%)	1:1 p=0.258	2:2 p=0.303	3:3 p=0.161	4:4 p=0.168	5:5 p=0.110
1	2	3	4	5	6	7
Ostryo-Quercetum	55.00000	22	14	2	1	1
Seslerio-Fagetum	65.95744	10	31	1	4	1
Abieti-Fagetum	68.00000	2	2	17	2	2
Homogino-Fagetum	53.84615	2	3	2	14	5
Lamio-Fagetum	29.41176	0	1	4	7	5
Total - *Ukupno*	57.41935	36	51	26	28	14

Table 8. Standardised coefficients for soil discriminant variables (according to thematic variables)
Tablica 8. Standardizirani koeficijenti za pedološke diskriminatorne varijable (prema tematskim varijablama)

Variable *Varijabla*		Standardised coefficients for discriminant variables *Standardizirani koeficijenti za diskriminatorne varijable*			
		First variable *Prva varijabla*	Second variable *Druga varijabla*	Third variable *Treća varijabla*	Fourth variable *Četvrta varijabla*
1		2	3	4	5
A_hum		.660440	-.015698	.211764	-.301591
A_N_uk		-.632466	.045263	.192146	-.433774
A_N_m		-.088606	-.306136	.458874	-.364603
(B)_hum		.212355	.734180	-.551441	-.282547
(B)_N_uk		-.808720	.061006	-.329858	.204924
(B)_N_m		.168345	-.599945	-.800576	-.178513
Eigenvalues *Svojstvene vrijednosti*	Single *Pojedinačno*	.894412	.338587	.116603	.017961
	Cumulative *Kumulativno*	.654019	.901603	.986866	1.000000

If the discriminating analysis according to the thematic variables is made separately for the A-, namely the (B)rz- horizon, the percentage of regularly classified profiles according to the A- horizon thematic variables comes off (Table 9). This refers in particular to the associations OST-QUE., SES-FAG. and HOM-FAG., where the percentage of properly classified profiles range between 17.5 and 23.5. Included here, the profiles of forest associations HOM-FAG. and SES-FAG. are mixed mostly with the forest association ABI-FAG. From the table of property values (Table 10), it can be seen that the first discriminatory variable explains the fo-

Figure 6. Scatterplot of soil discriminant variables (according to "thematic" variables)
Slika 6. Dijagram raspršenja pedoloških diskriminatornih varijabli (prema "tematskim" varijablama)



rest associations discrimination according to the A-horizon thematic variables with a percentage as high as 83%, while the other two are negligible. However, the classification matrix (Table 9) and the dispersion diagrams (Fig. 7) do not suggest any significant differences between the forest associations according to the indicated variables, with the exception, to a certain degree, of the ABI-FAG. and LAM-FAG., between which a certain discrimination exists (Fig. 7).

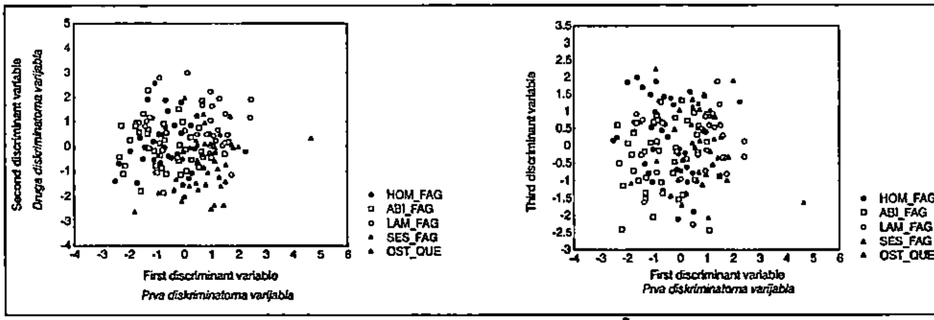
Table 9. Classification matrix of forest associations according to thematic variables of A-horizon
Tablica 9. Klasifikacijska matrica biljnih zajednica prema tematskim pedološkim varijablama A- horizonta

Forest associations *Biljne zajednice*	Correct *Ispravno* (%)	1:1 p=0.258	2:2 p=0.303	3:3 p=0.161	4:4 p=0.168	5:5 p=0.110
1	2	3	4	5	6	7
Ostryo-Quercetum	17.50000	7	29	2	1	1
Seslerio-Fagetum	65.95744	9	31	3	4	0
Abieti-Fagetum	48.00000	1	9	12	2	1
Homogino-Fagetum	19.23077	2	12	3	5	4
Lamio-Fagetum	23.52941	1	5	3	4	4
Total - *Ukupno*	38.06452	20	86	23	16	10

According to the (B)rz- horizon thematic variables, the percentage of properly classified profiles is in total the same as in the thematic variable analysis of the whole profile (Table 11). Significant here, however, is the decrease in the proper classification percentage for the forest association OST-QUE. (17.6 %) and the increase for the SES-FAG. (69.2%). The property values of the first and the second discriminatory variables are relatively high (Table 12), while the third one can be

Figure 8. Scatterplot of soil discriminant variables (according to "thematic" variables of (B)rz- horizon)

Slika 8. Dijagram raspršenja pedoloških diskriminatornih varijabli (prema "tematskim" varijablama (B)rz- horizonta)



relatively well discriminated from other forest associations, which is attributable to the macroclimatic and topoclimatic influence.

4. The forest associations discrimination according to the A- horizon thematic variables is markedly low (38% of properly classified profiles). A certain discrimination can be conjectured only between the ABI-FAG. and the LAM-FAG.

5. The phyocoenoses discrimination according to the (B)rz- horizon thematic variables is similar to that according to the thematic variables of the entire profile. There is a certain discrimination of the forest associations ABI-FAG. and HOM-FAG. from the others, as well as that of the SES-FAG. from the LAM-FAG.

DISCUSSION
RASPRAVA

In spite of the fact that the mathematical and statistical process modelling in forestry has been improved, in the investigation of certain ecosystem segments, such as soil, the problem is the large number of parameters to be included, as well as difficulties with their measurment. Experience has shown (Arrouys & Pelisser 1994, Arrouys et al. 1994, Berg 1980, Borchers & Perry 1992, Hršak 1993, Lohmyer & Zezschwitz 1982, Martinović 1972) that a reasonably acceptable solution in the investigation of such very dynamic systems consists in defining certain requirements in order to exclude uncontrolled influences (treatments). In the realisation of such a project, two basic questions arise:

1. Is the number of included parameters which can contribute significantly to the interpretation of relationships between the phenomena sufficient ?

2. Have all uncontrolled influences been excluded (namely, have the requirements been well defined) ?

The selection of variables used in this analysis and, through them, in the investigation of relationships in the soil, is based on the knowledge that the features of the soil organic matter, including those of brown soil over limestone, depend upon a number of interconnected stand conditions. With regard to the problems put forward in this work, the most important among them are: the plant tissue composition, the soil microorganism activity and soil chemical properties (Ćirić 1984, Lutz & Chandler 1962, Stevenson 1994). It is in this connection that the hypotheses on the organic complex variability in brown soil over limestone under various geomorphological and phytobioclimatic conditions of the western Croatia karst region have been presented.

With regard to the influence of forest associations, in this case of the phytobioclimates on the brown soil over limestone organic complex, the discriminating analysis has proved to be an excellent solution for the problem. The forest associations discrimination according to all measured variables is relatively high (81.95% of the properly classified pedological profiles). Nevertheless, only the pure beech stands (the forest associations SES-FAG., HOM-FAG. and LAM-FAG.) are separated well from the others, which can be attributed to the specific influence of litter. The forest associations discrimination based on the thematic pedological variables of the whole profile is less high, although the forest associations ABI-FAG. and HOM-FAG. are differentiated from the others. A likely reason for this is of the macroclimatic and topoclimatic nature and can be connected indirectly with the character of microbiological activity. A similar, though lower, discrimination is that according to the thematic (B)rz- horizon variables. If only the A-horizon thematic variables are taken into consideration, the discrimination is low (38% of properly classified profiles). The poor discrimination has been noted only between the forest associations ABI-FAG. and LAM-FAG. With regard to these findings, it can be said with certainty that in these relationships a number of factors with many interactive effects are involved.

CONCLUSIONS
ZAKLJUČCI

1. a) Discrimination of the five dominant forest associations in the karst region of western Croatia according to all measured pedological variables is relatively high (81.9% of properly classified pedological profiles). Within these, the littoral forest associations are distinguished well from the continental ones.

b) The discrimination of forest associations with pure beech stands from other forest associations has been determined and is attributable to the influence of litter.

2. In the discrimination of forest associations according to the geomorphological variables, the height above sea level dominates. This is also indicated by the canonical correlation between two sets of discriminatory variables.

3. The discrimination of forest associations according to the thematic pedological variables of the whole profile is less high than that according to all variables.

The beech and fir forest associations, as well as those of the sub-Alpine beech, are relatively well discriminated from other forest associations, which can be attributed to macroclimatic and topoclimatic influences.

4. The discrimination of forest associations according to the A- horizon thematic variables is markedly low (38% of properly classified profiles). A certain discriminati0and HOM-FAG. from the others, as well as a discrimination of the SES-FAG. from the LAM-FAG.

In general, the discriminating analysis has proved to be very suitable for the determination of the influence of vegetation on the organic complex features in brown soil over limestone. When a larger number of parameters is included, the forest associations discrimination is relatively high, owing to the pure beech stands, which can be attributed to the specific influence of litter. By reducing the number of variables, the forest associations discrimination decreases, which makes any firm conclusions difficult. In this connection, it can be assumed that these relationships include many factors with numerous interactive influences.

With the introduction of a larger number of parameters for the physiography of brown soil over limestone, the discriminating analysis would allow an even better explanation of its variability, especially in the topsoil, as well as its connection with the features of vegetation cover.

REFERENCES
LITERATURA

Arrouays, D., and Pelissier, P., 1994: Modeling Carbon Storage Profiles in Temperate Forest Humic Loamy Soils of France. Soil Sci. 157(3): 185-192.

Arrouays, D. I. Vion, and Kicin, J. L., 1995: Spatial analysis and modeling of topsoil carbon temperate forest humic loamy soils of France. Soil Sci. 159(3): 191-198.

Babel, U., 1972: Moderprofile in Waldern. Eugen Ulmer, Stuttgart, 120 pp.

Berg, R. C., 1980: Use of Stepwise Discriminant Analysis to Assess Soil Genesis in a Youngful Sandy Environment. Soil Sci. 129(6): 353-365.

Bertović, S., 1971: Ekološko-vegetacijske značajke Zavižana u sjevernom Velebitu. Glas. šum pokuse 18: 5-75.

Borchers, J. G., and Perry, D. A., 1992: The influence of soil texture and aggregation on carbon and nitrogen dynamics in southwest Oregon forests and clearcuts. Can. Journal of Forest Research 22(3): 298-305.

Christensen, B. T., and Malmros, P. A., 1984: Spatial variability of litterfall and soil organic matter in a beech stand. Forstlige Forsogsvaesen i Danmark 39(3): 383-396.

Cline, M. D., 1944: Principles of soil sampling. Soil Sci. 58: 275-288.

Ćirić, M., 1984: Pedologija. Svjetlost, Sarajevo, 310 pp.

Fridland, V. M., 1984: Struktura pochvenogo pokrova mira. Misli, Moskva, 234 pp.

Gračanin, M., 1931: Pedološka istraživanja Senja i bliže okolice. Glas. šum. pokuse 3: 1-52.

Gračanin, Z., 1972: Vertikale und horizontale Verteilung der Bodenbildung auf Kalken und Dolomiten im mittleren Abschnitt der Alpen. Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 15: 19-40.

Hayes, M. H. B., and Swift, R. S., 1981: Organic colloids and organo-mineral associations. Bull. Intern. Soc. Soil Sci. 60: 67-74.

Homann, P. S., Sollins, P., Chappel, H. N., and Stangenberger, A.G., 1995: Soil Organic Carbon in a Mountainous, Forested Region: Relation to Site Characteristics. Soil Sci. Soc. Am. J. 59: 1468-1475.

Horvat, I., 1962: Vegetacija planina zapadne Hrvatske, sa 4 karte biljnih zajednica sekcije Sušak. Prirodoslovna istraživanja JAZU, vol. 30, Zagreb, 179 pp.

Hršak, V., 1993: Mineralizacija dušika u tlu nekih travnjačkih fitocenoza u okolici Zagreba (disertacija). Prirodoslovno matematički fakultet Sveučilišta u Zagrebu, Zagreb, 131 pp..

Jenny, H., 1930: Soil organic matter-temperature relationship in the eastern United States. Soil Sci. 247-252.

Jenny, H., 1941: Factors of Soil Formation. A System of Quantitative Pedology. McGraw-Hill Book Company, Inc. New York, London, 281 pp.

Jenny, H., 1958: Role of the Plant Factor in the Pedogenic Functions. Ecology 39(1): 5-16.

Jović, N., 1969: Karakter i grupnofrakcioni sastav humusa genetičko evolucione serije zemljišta na krečnjaku pod munikom (*Pinetum heldreichii* Horv. 1963). Zemljište i biljka 18(1-2): 59-70.

Koegel, I., Hempfling, R., Zech, W., Hatcher, P. G., and Schulten, H. R., 1988: Chemical composition of the organic matter in forest soils: 1. Forest litter. Soil Sci. 146(2): 124-136.

Kumada, K., 1987: Chemistry of soil organic matter. Development in soil science 17. Japan Sci. Soc. press., 241 pp.

Kundler, P., 1963: Einfluss verschiedenartiger Waldbestande auf die Bodenentwicklung. Archiv für Forstwesen 12(7): 659-675.

Lohmeyer, W., and v. Zezschwitz, E., 1982: Einfluss von Reliefform und Exposition auf Vegetation, Humusform und Humusqualität. Geol. Jb. 11: 33-70.

Lutz, H. J., and Chandler, R. F., 1962: Šumska zemljišta. Naučna knjiga, Beograd, 350 pp.

Mardia, K. V., Kent, J. T., and Bibby, J. M., 1982: Multivariate analysis. Academic press, London, Orlando.

Martinović, J., 1972: Zavisnost stepena humizacije od stanišnih uslova u šumskim tlima na karstu zapadne Hrvatske (disertacija). Šumarski fakultet Univerziteta u Sarajevu, Sarajevo, 99 pp.

Martinović, J., 1990: Pedološka karta Hrvatske (manuscript). Zagreb.

Mayer, B., 1980: Tla sekcije Ogulin 2. Projektni savjet za izradu pedološke karte SR Hrvatske, Zagreb, 59 pp.

Mayer, B., 1992: Šumska tla Republike hrvatske pri kraju XX. stoljeća. In: Rauš, Đ. (ed.), Šume u Hrvatskoj, Šumarski Fakultet Sveučilišta u Zagrebu and "Hrvatske Šume", p.o. Zagreb, Zagreb, pp. 19-32.

Mcnabb, D. H., Cromack, K., Jr., and Fredriksen, R.L., 1986: Variability of nitrogen and carbon in surface soils of six forest types in the Oregon Cascades. Soil Sci. Soc. Am. J. 50: 1037-1041.

Pelcer, Z., and Martinović, J., 1990: Odnos tla i šumske vegetacije na području Gorskoga Kotara i Like (manuscript). Zagreb.

Rauš, Đ., Trinajstić, I., Vukelić, J., and Medvedović, J., 1992: Biljni svijet hrvatskih šuma. In: Rauš, Đ. (ed.), Šume u Hrvatskoj, Šumarski Fakultet Sveučilišta u Zagrebu and "Hrvatske Šume", p.o. Zagreb, Zagreb, pp. 38-78.

Stevenson, F. J., 1994: Humus Chemistry; Genesis, Composition, Reactions (2nd ed.). John Wiley, Sons, Inc. New York - Chichester - Brisbane - Toronto - Singapore, 496 pp.

Stritar, A., Osole, F., and Gregorić, V., 1967: Prilog poznavanju geneze zemljišta na vapnencima. Zemljište i biljka, 16(1-3): 563-572.

Taboada, B. M., and Silva, B. M., 1994: Genetical Relationships of a Toposequence of Soils over Limestone. In: Etchevers, J. D. (ed.), 15th World congress of soil science, International society of soil science, vol. 6b, pp. 86-87.
Trinajstić, I., 1970: Hoehenguirtel der Vegetation und die Vegetationsprofile im Velebit Gebirge. Mittl. Ostalp.-din. Ges. f. Vegetkde. 11: 219-224.
Vranković, A., 1971: Pedološki prikaz tala nekih šumsko-gospodarskih jedinica u području masiva Mala Kapela. Šum. list 94(11-12): 369-390.
Wraber, M., 1967: Genetska veza između vegetacijskih i talnih jedinica na karbonatnom području visokog krša Slovenije. Zemljište i biljka 16(1-3): 557-564.
Zonn, S. V., 1960: Uticaj šume na zemljište. Biblioteka Jugoslavenske nacionalne komisije za topolu, knjiga 4.
Živanov, N., 1962: Prilog poznavanju prostorne varijabilnosti šumskih zemljišta. Narodni šumar 16(7-9): 383-385.

ODNOS TLA I ŠUMSKE VEGETACIJE U SVJETLU RAŠČLAMBE NEKIH SVOJSTAVA SMEĐEGA TLA NA VAPNENCU NA KRŠU ZAPADNE HRVATSKE

SAŽETAK

U radu je istraživan utjecaj vegetacije na svojstva smeđega tla na vapnencu na kršu zapadne Hrvatske. Cilj je bio istražiti neke fiziografske značajke smeđega tla na vapnencu i provjeriti na taj način hipoteze iz dosadašnjih istraživanja slične naravi, u kojima se govori o:

- visokoj varijabilnosti fiziografskih svojstava smeđega tla na vapnencu, poglavito onih koji su u izravnoj ili posrednoj vezi s organskom tvari tla, tj. svojstava površinskoga dijela tla;

- uzročnoj povezanosti te varijabilnosti s: drugim pedofiziografskim svojstvima, klimatskim čimbenicima, vegetacijskim čimbenicima, geomorfološkim čimbenicima.

Ovdje je postavljen zadatak da se na temelju odabranih relativnih pokazatelja stanja organske tvari tla i ekosustava u cjelini istraže zakonitosti u pretpostavljenim odnosima, poglavito između svojstava smeđega tla na vapnencu i vegetacije (šumskih fitocenoza).

Riječ je o ovim pokazateljima:

a)klimatskozonska pripadnost vegetacije
b) debljina pedogenetičkih horizonata i dubina tla
c) reakcija A- i (B)- horizonta tla
d) sadržaj humusa u A- i (B)- horizontu tla
e) sadržaj ukupnoga i mineralnih oblika dušika u A- i (B)- horizontu tla
f) sadržaj fiziološki aktivnih oblika fosfora i kalija u A- i (B)- horizontu tla
g) sadržaj gline u A- i (B)- horizontu tla
h) grupni sastav humusa u A- horizontu tla.

Istraživanja su obavljena u zapadnoj Hrvatskoj, na kršu (vapnenačko-dolomitno područje), i to u sljedećim, u tom području dominantnim klimatskozonskim fitocenozama:

1. *Ostryo-Quercetum pubescentis* /Ht./ Trinajstić 1977
- mješovite šume medunca i crnoga graba
2. *Seslerio-Fagetum sylvaticae* /Ht. 1950/ M. Wraber 1960
- šuma bukve i jesenske šašike
3. *Abieti-Fagetum dinaricum* Treg. 1957
- dinarska bukovo-jelova šuma
4. *Homogino alpinae-Fagetum sylvaticae* /Ht. 1938/ Borh. 1963
- pretplaninska bukova šuma s urezicom
5. *Lamio orvale-Fagetum sylvaticae* Ht. 1938
- brdska bukova šuma s mrtvom koprivom.

U statističkom dijelu istraživanja primijenjena je diskriminantna analiza fitocenoza prema mjerenim pedološkim varijablama. Rezultati istraživanja mogu se sažeti na ovaj način:

- Prema svim mjerenim pedološkim varijablama pokazale su se vrlo značajne razlike između fitocenoza. Pritom je osobito dobro razdvojena skupina primorskih od kontinentalnih fitocenoza. Iz toga se može usvojiti zaključak o jasno prepoznatljivom, specifičnom utjecaju u istraživanja uključenih biljnih zajednica, na fiziografska svojstva tla. Što se tiče specifičnog utjecaja biljne vrste (iako istraživanja nisu bila tomu usmjerena), on se može prepoznati u fitocenozama sa čistim bukovim sastojinama (SES-FAG., HOM-FAG. i LAM-FAG.), što se može pripisati ponajprije utjecaju listinca (organskog otpada). Diskriminacija fitocenoza prema "tematskim" pedološkim varijablama cijeloga profila slabija je nego prema svim varijablama. Bukovo - jelove i pretplaninske bukove fitocenoze relativno su dobro diskriminirane od ostalih fitocenoza, što se može pripisati makroklimatskom i topoklimatskom utjecaju. Još je slabija diskriminacija fitocenoza posebno prema A-, odnosno (B)rz- horizontu. Općenito, pokazalo se da je diskriminantna analiza vrlo pogodna za determinaciju vegetacijskog utjecaja na značajke organskoga kompleksa smeđega tla na vapnencu, odnosno raščlambu varijabilnosti njegovih svojstava. Smanjenjem broja varijabli opada i diskriminacija fitocenoza, što otežava donošenje čvrstih zaključaka. U svezi s tim može se pretpostaviti da je u te odnose uključen niz čimbenika s brojnim interakcijskim utjecajima. Uključenjem većega broja pedofiziografskih parametara mogla bi se diskriminantnom analizom još bolje objasniti njihova varijabilnost, odnosno povezanost s vegetacijskim značajkama, definiranima biljnosociološkom pripadnošću.

Ključne riječi: smeđe tlo na vapnencu, organska tvar tla, humus, vegetacija, krš