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SOILS OF THE MYCOLOGICAL RESERVE ON LISINA MOUNTAIN IN THE REPUBLIC OF SRPSKA, BOSNIA AND HERZEGOVINA

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Abstract - This paper presents the results of soil research in a mycological reserve that is defined as a special nature reserve according to the IUCN categorization. Ecologically, fungi are the most valuable element in the biological diversity of protected reserves. Favorable climate and the complexity of geology, soils and vegetation of Lisina Mountain caused the development of extraordinarily rich mycoflora. The soil cover here is characterized mainly by soils on acid siliceous parent rocks. Carbonate sediments as a part of volcanic sediment formation, present with laminated black limestone, complicate the structure of the soil cover. The protected area is defined by five basic soil types: rendzina, ranker, dystric cambisols, luvisol and podzol. Soil properties depend on pedogenetic processes and the nature of the parent rock. Rendzina is the most common soil type on limestone-dolomite substrate, where it creates elementary and complex soil combinations, mainly because of its strong relief. The most common soil type on acid silicate rocks is dystric cambisols.

Key words: Mycological reserve, Lisina, soils, production potential,Republic of Srpska, Bosnia and Herzegovina

INTRODUCTION

The modern conception of nature primarily involves the protection and promotion of vital elements of biodiversity, ecologically valuable ecosystems and landscapes. Soil is a very important component of forest ecosystems and it is the main factor that, through the effects of climate-orographic elements, reflects on environmental conditions and the production potential (Knežević and Košanin, 2008). The variability of soil significantly conditions the existing biological and ecological diversity in natural areas. The main objective of this study arises from the fact that forest soils are not explored enough, and because of the real necessity to determine the ecological and production capacity of the habitat, thereby setting the base for the preservation of uniqueness, rarity and representativeness of ecosystems and habitats. The detailed research of soils given here should be the starting point in defining the correlations between different soil types and the most valuable species of fungi, as well as for optimal use of habitat potential opportunities and preservation of ecological and production values.

Research area

The mycological reserve of Lisina is the only one of its kind in the Republic of Srpska, and Europe. It was put under protection in 2011 as an area of the special nature reserve "Lisina" by an act of the competent Ministry. It covers 550.64 hectares in the central part of Mt. Lisina. This mountain (1 467 m above sea level) is located in the inner part of the Dinaric Mountains

Map 1. Geographical location of Lisina mountain

in western Bosnia and Herzegovina (southwestern Republic of Srpska), in the Bosnian Krajina area. It is located at 44° 23' 51" latitude and 17° 02' 30" longitude. In this rectangle, the expanding direction of Lisina is NW-SE (Map 1).

The climate of this area is perhumid. At 1100 m a.s.l., the average annual temperature is 6.8°C; in the growing season it is 12.4°C. The average annual amount of rainfall is 1.371 mm, and during the growing season 702 mm (Eremija, 2010).

The geology is very complex, since different geological formations coexist in this small area (Mudrenović, 1991). The study area is mostly covered with volcanic sedimentary formations, which are characterized by a very heterogeneous lithological composition. In this heterogeneous petrographic composition, siliceous rocks are dominant and the main characteristic is fast mechanical decomposition. Another important feature of this silicate is its lithological, mineralogical and stratigraphic heterogeneity (Ciric et al., 1975). Carbonate sediments are presented by dolomite and blocky black bituminous limestone with ammonites – extinct marine creatures that have a hard, spirally coiled shell. The existence of different rocks in a relatively small area and their relatively rapid shift is reflected on the soil quality, and consequently on other environmental elements. The altitude of this protected area is between 1000 and 1467 m a.s.l. The area is hydrologically very rich, which is related to its geological composition. Very productive mixed forests of beech and fir with spruce (*Piceo-Abieti-Fagetum* Stef. et al. 1986.) are dominant in this protected natural area.

MATERIALS AND METHODS

In the research area, 11 soil profiles were opened, external and internal profile morphology was explored, genetic horizons are separated, and soil samples were taken in disordered condition for the laboratory testing of physical and chemical soil properties in accordance with the standard methodology in the laboratory of the Faculty of Forestry in Belgrade. Analytical laboratory values of the physical and chemical properties of the representative profiles of defined soil types are shown in Table 1 and Table 2. Based on the field research and analytical data obtained from the laboratory, pedosystematic units were defined according to the principles of the Classification system of Škorić et al. (1985). The production potential of defined types and lower soil systematic units was evaluated.

RESULTS AND DISCUSSION

This research shows a relatively high number of different soil creations that occur in a small area of the protected reserve "Lisina". The geological heterogeneity and dynamism of the relief with the impact of a humid climate caused the formation of different soil types with different properties and production potential. Soil forming on a variety of geological substrates takes place in different directions. The length and slope steepness are especially important elements of relief. In this Reserve, the largest area is covered by soils formed on acid silicate rocks. There is a formation of dolomite and black bituminous limestone with the remains of ammonites. On silicate parent rocks, the following soil types occur: ranker, dystric cambisol, luvisol and podzol. On limestone-dolomite geological formations, rendzina and ilimerised soil are distinguished.

Rendzina

As regards the native substrate, three subtypes of rendzina are defined: on dolomite, on limestone with ammonites and on soft limestone. Rendzina on dolomite appears on flat parts, milder and equable slopes, with small depth and regolithic contact with the parent material, which deepens the physiologically active thickness. The subtype on limestone with ammonites is up to 70 cm deep, with medium amount of stones (skeletal), while rendzina on soft limestone is 20-40 cm thick and it is low-to-medium skeletal. This soil is characterized by sandy-loamy particle size distribution and a high content of fine sand fractions. The soils are well structured, mainly of grain-to-crumb structure. The high content of active carbonate is a very important characteristic and has a crucial influence on its chemical properties. Carbonates cause neutral-to-moderately alkaline reaction and unsaturated colloid complex. They are rich in humus and nitrogen. These soils are eutrophic with deficiency only in phosphorus. The availability of some nutrients may be limited due to the high concentration of $CaCO_3$. The characteristics of evolutionarily younger calcareous soils are often caused by parent rocks and relief (Kapović et al., 2013). Productivity is determined by the depth of their physiologically active profile and site conditions, so rendzina may be considered as a medium-productive forest soil. A low water-holding capacity due to the sandy texture is the most critical element of fertility, and this deficiency may be compensated by the humid character of climate.

Humus – siliceous soil (Ranker)

Ranker is developed locally on steep slopes and prominent ridges. It is defined as a dystric subtype, relatively shallow, with lithic contact. The humus-accumulative horizon is green-brown colored, fine-grained, low-to-moderate skeletal. It is characterized by a sandy-loamy texture and high content of coarse sand fractions. Because of the sandy texture, the soil is porous and loose, and due to the small depth it dries quickly and easily. The reaction is strongly-to-extremely acidic. The elevation, mountainous climate and type of forest vegetation contribute to the high acidity of the soil. This ranker subtype is characterized by a poor adsorptive complex and high hydrolytic acidity, which determines the composition and quality of the humus. On the other hand, we have a high exchange capacity (T), which is derived from the high humus content. Dystric ranker is a soil with low production potential, caused by its shallowness, the physical condition of the substrate, biological activity and microclimate. Its local character is important in terms of habitat diversity.

Acid brown soil (Dystric Cambisol)

Typical subtypes of dystric cambisol are developed on silicate geological formations. The forming of this soil type was mainly related to moderate slopes with an angle up to 20° and the appearance of crystalline shale rocks. Miloš (1979) suggests that there is a strong relationship between the properties of dystric cambisol and the substrate. These cambisols are moderately deep-to-deep soils. The loamy texture with a stable spheroid (crumbly) structure provides a favourable water-air soil regime. One of the main features of this soil texture is the high content of skeletal material, especially in cambic horizons, which causes high aeration and water permeability. It is characterized by a low content of adsorbed bases, low base saturation and very acid reaction, which results in a somewhat destructive decomposition of clay minerals. The low concentration of the base (not exceeding 30%) is caused by the parent material. The chemical properties of dystric cambisol are often caused by the siliceous substrate where this soil type is developed (Kapović et al., 2011). The richness of humus in the humus-accumulative horizon is certainly one of the most important chemical properties. It is also characterized by a medium content of available potassium forms and low content of phosphorus. The importance of the substrate is reflected particularly in the trophic status and soil reaction. Nutrient deficit is a typical feature of dystric cambisols formed on all substrates (Mrvić et al., 2010). The C/N ratio indicates that the chemical nature of organic matter provides favourable conditions for mineralization and release of plant assimilative. Typically, the acid brown soils here are characterized by a highly productive habitat for mixed forests of beech, fir and spruce. The soil production potential is highly correlated with the depth of the solum, skeletal content and texture. Košanin and Knežević (2006, 2007) showed that dystric cambisol productivity is in the function of depth and skeletal content for almost all parent rocks. Deeper forms with a lower content of skeletal soil have a higher ecological production value.

Ilimerised soil (Luvisol)

Ilimerised soil occurs where conditions allow the formation of a deeper soil profile. For its formation, the crucial role is that of relief as a pedogenetic factor. It is prevalently related to plateaus and gentler relief forms. Regarding to the substrate, two subtypes of luvisol are defined: on limestone and shale. The profile morphology of both subtypes is characterized by an eluvial E-horizon. Textural differentiation is prominent and the clay content increases with depth. The physical properties of these defined subtypes are different. The subtype on shale has more favorable physical properties. It is deeper, with lighter textural composition, and the presence of small-to-medium skeletal fragments has a favorable effect on soil filtration capability. The chemical properties of both subtypes are characterized by acid reaction and low saturation of alkali captions. The main factor of adsorptive capacity is humus. The base saturation degree in the entire depth of the solum is less than 50%, while the lowest value was found in the eluvial horizon, which is a typical feature of ilimerised soil. A high humus, nitrogen and potassium content were found in the humus layer, while it decreases rapidly with depth. Phosphorus is scarce. The productive capacity of luvisol in the mycological Reserve is high. The subtype on shale shows a higher production potential compared to the subtype on limestone, which is primarily a reflection of the differences in physical properties. Knežević and Košanin (2007) confirmed the dependence between the luvisol production potential and its physical properties. A deeper solum, slightly lighter particle size distribution and better drainage provide higher production potential. Luvisol on limestone is poorer than the siliceous subtype, which is especially visible at higher altitudes where the tendency of humus forming is more expressed (Kapović, 2013). However, under the influence of the humid mountainous climate, the limestone subtype is also very productive for beech, fir and spruce forests.

Podzol

In the special nature reserve "Lisina", the distribution of podzol is very limited, which is primarily due to an extremely acidic parent material and unfavorable composition of organic residue. Given the differences between the properties of the Bt horizon, the ferrous subtype is separated, variety is moderate podzol, with the depth of the E horizon from 10 to 20 cm. The morphology of the profile is characterized by a clear

Table 1. Physical properties of the analyzed soil profiles

Profile No.	Horizon	Depth (cm)	Hygroscopic water (%)	Granulometric composition of soil (%)								Texture class
				2.0 – 0.2 mm	0.2 – 0.06 mm	0.06 – 0.02 mm	0.02 – 0.006 mm	0.006 – 0.002 mm	less than 0.002 mm	Total		
										Sand	Clay	
1	3	4	5	6	7	8	9	10	11	12	13	14
Rendzina on dolomite												
1/12	A	0-25	4.10	3.00	65.50	14.60	6.60	2.10	8.20	83.10	16.90	Loamy sandy soil
2/12	A	0-20	3.98	8.20	52.40	15.80	9.80	3.90	9.90	76.40	23.60	Sandy loam
Rendzina on limestone with ammonite												
3/12	A	0-17	5.71	5.40	54.50	19.60	9.00	1.80	9.70	79.50	20.50	Sandy loam
	A	17-70	1.47	2.10	48.00	20.20	13.60	3.20	12.90	70.30	29.70	
4/12	A	0-7	6.58	2.10	61.90	13.70	9.90	3.50	8.90	77.70	22.30	Loamy sandy soil
	A	7-45	3.24	2.10	70.40	9.50	7.10	2.80	8.10	82.00	18.00	
Rendzina on soft limestone												
5/12	A	0-30	6.24	3.70	45.00	15.50	16.00	7.20	12.60	64.20	35.80	Sandy loam
Ranker												
6/12	A	0-25	2.53	44.20	8.30	6.70	18.40	9.10	13.30	59.20	40.80	Sandy loam
Dystric cambisol												
7/12	A	0-7	3.44	17.00	16.30	13.60	26.80	9.20	17.10	46.90	53.10	Loam
	(B)	7-65	2.13	8.30	13.50	14.00	28.40	12.80	23.00	35.80	64.20	Loam
8/12	A	0-8	4.1	15.20	14.00	13.70	22.10	14.70	20.30	42.90	57.10	Loam
	(B)	8-55	3.02	14.90	11.00	9.60	23.40	13.30	27.80	35.50	64.50	Clay loam
Ilimerised soil on limestone												
9/12	A	0-8	3.9	3.70	12.50	21.60	33.80	12.20	16.20	37.80	62.20	Loam
	E	8-30	2.68	3.00	3.60	19.50	34.70	16.40	22.80	26.10	73.90	Silty loam
	B	30-80	3.83	3.90	4.30	12.70	25.70	12.60	40.80	20.90	79.10	Clays
Ilimerised soil on shales												
10/12	A	0-7	3.36	0.40	5.40	22.20	36.30	15.40	20.30	28.00	72.00	Silty loam
	E	7-35	3.34	0.30	0.00	16.80	32.10	17.60	33.20	17.10	82.90	Loam
	Bt	35-85	6.63	0.30	0.20	8.90	4.40	5.30	80.90	9.40	90.60	Clays
Podzol												
11/12	Olfh	0-7	8.30	4.00	45.80	26.10	11.90	3.80	8.40	75.90	24.10	Sand loam
	E	7-27	0.90	12.90	13.20	15.50	38.70	9.90	9.80	41.60	58.40	Loam
	Bt	27-45	2.89	9.50	7.60	9.90	22.10	15.80	35.10	27.00	73.00	Clay loam

Table 2. Chemical properties of analyzed soil profiles

Profile No.	Horizon	Depth (cm)	pH		Y1 mL NaOH/ 50g	Adsorptive complex				$CaCO_3$	Humus	C	N	C/N		
						(T-S)	S	T	V						P_2O_5	K_2O
			H_2O	$CaCl_2$		cmol/kg			(%)	(%)	(%)	(%)	(%)		mg/100g	
1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Rendzina on dolomite																
3/10	A	0-25	8.01	7.43	-	-	-	-	-	49.51	9.22	5.35	0.45	11.90	0.50	7.00
7/10	A	0-20	8.09	7.59	-	-	-	-	-	38.78	13.22	7.67	0.65	11.80	0.35	11.90
Rendzina on limestone with ammonite																
2/10	A	0-17	7.75	7.21	-	-	-	-	-	28.41	19.00	11.02	0.66	16.70	3.40	9.60
	A	17-70	8.17	7.50	-	-	-	-	-	54.99	3.28	1.90	0.18	10.50	0.45	4.70
22/10	A	0-7	7.70	7.24	-	-	-	-	-	38.34	19.25	11.16	0.86	12.90	0.70	10.50
	A	7-45	7.98	7.41	-	-	-	-	-	50.58	8.04	4.66	0.40	11.60	0.05	5.00
Rendzina on soft limestone																
25/10	A	0-30	7.86	7.33	-	-	-	-	-	21.00	13.10	7.60	0.70	10.80	0.10	10.80
Ranker																
11/10	A	0-25	4.60	3.81	52.50	34.12	7.40	41.52	17.82	-	6.75	3.91	0.40	9.80	2.30	16.40
Dystric cambisol																
17/10	A	0-7	4.62	3.85	69.50	45.17	7.70	52.87	14.56	-	9.43	5.47	0.42	10.30	0.60	16.10
	(B)	7-65	5.59	4.59	26.75	17.39	7.00	24.39	28.70	-	1.74	1.01	0.15	-	-	8.80
24/10	A	0-8	5.09	4.11	62.00	40.30	13.00	53.30	24.39	-	9.17	5.32	0.53	10.00	0.40	14.50
	(B)	8-55	4.97	4.16	49.75	32.34	8.60	40.94	21.01	-	1.96	1.13	0.12	9.40	0.05	9.80
Ilimerised soil on limestone																
21/10	A	0-8	4.87	4.06	55.75	44.69	15.10	59.79	25.25	-	10.26	5.95	0.41	14.50	0.80	9.80
	E	8-30	5.43	4.55	40.00	26.00	11.80	37.80	31.22	-	3.00	1.74	0.16	10.80	-	8.10
	B	30-80	5.93	4.87	30.62	19.90	16.20	36.10	44.87	-	1.48	0.86	-	-	-	10.40
Ilimerised soil on shales																
29/11	A	0-7	4.86	3.95	69.30	45.04	4.40	49.44	8.90	-	5.67	3.29	0.34	9.7	0.40	9.27
	E	7-35	5.13	4.18	46.16	30.00	-	30.00	-	-	2.69	1.56	0.22	7.10	0.40	5.43
	Bt	35-85	5.25	4.04	63.95	41.56	11.40	52.96	21.53	-	1.10	0.64	-	-	0.30	13.25
Podzol																
30/11	Olfh	0-7	4.35	3.20	200.00	130.00	13.60	143.60	9.47	-	50.90	29.53	1.31	22.50	13.10	30.50
	E	7-27	4.20	3.23	33.50	21.78	-	21.78	-	-	1.67	0.97	0.10	9.70	1.00	4.50
	Bt	27-45	4.53	3.65	77.11	50.12	-	50.12	-	-	1.48	0.86	-	-	-	5.85

differentiation in color and particle size distribution. Soil texture up to the B horizon is sandy loam-to-loam, and the illuvial horizon is clay-loam. The soil is skeletal, which increases water permeability. As a result of illuviation, the content of colloidal clay and compactness are increased in the Bt horizon, which slows down water filtration from the upper horizons. The clay content in podzol is very important, because clay resists the podsolisation process. Chemical properties are characterized by an extremely acid reaction. The main reserves of mineral elements contained in the O horizon are in inert form because of high acidity and wide C/N ratio, which prevent their biotransformation. The production potential is very low, and the limiting factor is primarily a low biological activity and extreme acidity. Despite the low productivity, podzol is significant in terms of habitat diversity, because it is a very rare soil type and it can be developed only under specific conditions (Kapović, 2013).

CONCLUSIONS

The soil of the mycological reserve "Lisina" is varied and complex. The expressed variability of basic pedogenetic factors, complex geological-petrographic structure, macro- and mesorelief, influence of the regional macro- and local microclimate, as well as the active influence of vegetation, have caused the high variability of the soil cover in terms of evolutionary-genetic development and in terms of basic properties. Constellations of petrographic-mineralogical composition and the form of the mesorelief with other site conditions influence the appearance of certain soil types or subtypes. The highest participation in the soil cover is that of soils formed on silicate bedrock. Due to the pronounced relief, the most common type of soil is dystric cambisol. Rendzina is the most common type of soil on limestone, where elementary soil areas and complex soil combinations are built. The ecological-production value of soil is highly correlated to the soil depth. Although depth represents an important factor for productivity, its impact should be observed and connected with soil type, climate and other site conditions. Soils with a high productive potential are luvisol (both subtypes), dystric cambisols and deeper forms of rendzina on limestone with ammonites, and these are deep and have a favorable texture and moderate skeletal content. A type of soil with a medium production potential is the shallower form of rendzina, which is caused primarily by the development level and depth. Ranker and podzol have a low productivity, and the main limiting factors here are shallowness (ranker) and low biological activity (podzol). Soils with a high ecological-production potential should be managed in accordance with the criteria and principles of rational, sustainable and multifunctional forest management. Because they represent a first-class edaphic rarity in this section, podzol sites should be allocated, mapped and protected in terms of habitat diversity.

REFERENCES

Ćirić, M., Burlica, Č., Vukorep, I. and *V. Beus* (1975). *Uticaj stanišnih faktora na produktivnost bukovih šuma u BiH*, ANU BiH, Posebna izdanja XXIII, Simpozijum o problemima istraživanja šumskih zemljišta, Sarajevo.

Eremija, S. (2010). *Klimatske karakteristike visinskih pojaseva planine Lisina kod Mrkonjić Grada*. Šumarstvo, br. 1-2, Udruženje šumarskih inženjera i tehničara Srbije, Beograd, 107-116.

Kapović, M. (2013). *„Šumska zemljišta planine Javor u Republici Srpskoj"*, Doktorska disertacija odbranjena na Šumarskom fakultetu Univerziteta u Beogradu.

Kapović, M., Knežević, M. and *V. Blagojević* (2011). *Characteristics and variability of dystric brown soils in Posavsko forest economic district. Bulletin of the Faculty of Forestry* **104**, pp 71-80.

Kapović, M., Tošič, R., Knežević, M. and *N. Lovrić* (2013). *Assessment of Soil properties under degraded forests: Javor Mountain in Republic of Srpska* - a Case study, *Arch. Biol. Sci.*, Belgrade, 65 (2), 631 - 638, 2013 DOI:10.2298/ABS1302631K631

Knežević, M., and *O. Košanin* (2007). *Ilimerizovano zemljište (Luvisol) u šumi bukve, jele i smrče na Tari*. Zemljište i biljka, vol. 56, br. 1, Unija bioloških naučnih društava Jugoslavije, Beograd, str. 1-9.

Knežević, M. and *O. Košanin* (2008). *Šumska zemljišta Zlatara*. Šumarstvo, br. 3, Udruženje šumarskih inženjera i tehničara Srbije, Beograd, str. 137-144.

Košanin, O. and *M. Knežević* (2006). *Edafski uslovi nekih hrastovih zajednica na silikatnim supstratima Srbije*, *Šumarstvo* 1-2, UŠITS, Beograd (47-57)

Košanin, O. and *M. Knežević* (2007). *Šumska zemljišta u G.J. "Čezava" N.P. "Đerdap"*, Šumarstvo 1-2, UŠITS, Beograd (25-38).

Miloš, B. (1979). *Značaj svojstava distričnog kambisola za proizvodnost bukve u Bosni,* Magistarski rad, Šumarski fakultet Univerziteta u Sarajevu, Sarajevo.

Mrvić V., Antonović, G. M., Nikoloski, M., Kravljanac-Kostić, L., Čakmak, D., Saljnikov, E. and *V. Perović* (2010). *Pedosekvence na spilitima,* Acta biologica Jugoslavica - serija A, Zemljište i biljka 3, vol. 59, Jugoslovensko društvo za proučavanje zemljišta, Beograd (195-206).

Stefanović, V. (1986): *Fitocenologija*, Svjetlost, zavod za udžbenike i nastavna sredstva, Sarajevo.

Škorić, A., Filipovski G., and *M. Ćirić* (1985). *Klasifikacija zemljišta Jugoslavije*, Posebno izdanje, knjiga LXXVIII. Odjeljenje prirodnih i matematičkih nauka, knjiga 13. Akademija nauka i umjetnosti BiH, Sarajevo.

Mudrenović, V. (1991). "*Stratigrafija trijasa planina Lisine i Dimitora*". Doktorska disertacija, Rudarsko - geološki fakultet, Beograd.