

Soil catenas and plant sites on the northern macroslope of Rila Mountain

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ABSTRACT

The following paper represents results from a research focused on the soil associations and their corresponding vegetation communities (soil-plant catenas), located on the northern slopes (N, NW, NE) of the Rila Mountains. Data from eight key sites located between 815 and 2041 m above sea level is discussed. The slope in each site varies from 2° to 25°, and most often the tests and descriptions were carried out on sites with a slope of 10-15°. Vegetation cover is analyzed with plant community plots which provides data on species composition, abundance and coverage. The size of each plot varies from 16 up to 225 m² depending on the vegetation type. Topsoil horizons were tested in each site in order to diagnose the subspecies diversity of brown forest soils (Cambisols) using ratio of humic acids to fulvic acids. That ratio varies from 0,69 up to 1,61 in all studied sites. Both acids are associated with the dominance of different vegetation types – deciduous, mixed or coniferous forest or herbaceous canopy. The results are interrupted in terms of the diagnosis and classification of Cambisols and Umbrosols in the area of interest. Differences in soil and vegetation cover of Northwest and Eastern Rila Mountain are highlighted and analyzed.

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1. Introduction

Soil catenas are units of soil mapping, which denote combinations between different soils, united in the process of their formation and development of a certain type of relief, relief-forming processes and a uniform rock base. The catena approach corresponds to the landscape-geochemical concept. According to Sarafov and Popov (1990), the two concepts complement each other - while the catenas approach reveals the relative weight of individual factors in the soil formation process, the landscape-geochemical approach reveals the nature and mechanism of the soil formation process itself.

According to Gerrard (1981), catenas are the product of two types of factors - static and dynamic. The most dynamic is the interaction between soil and vegetation. Therefore, soil-plant associations in transects on a given macroslope with the same exposure are subject to comparative analysis.

The catena approach (Milne, 1935; Scheidegger, 1986, 2004) is applicable to the study of the relationship between weathering and soil formation. Gennadiev and Zhidkin (2012) base their study on the typification of soil catenas on slopes. Urusevskaya (2017) conduct a research on soil catenas in the northern taiga zones of the Kola Peninsula. Jandl et al. (2019) study erosion induced heterogeneity soil catenae in Baltic Sea Catchment. Borden et al. (2020) investigate the East African contribution to soil catenas' studies. Shamrikova et al. (2022) conduct a soil and vegetation research in Polar Urals.

The change in soils and their properties is also associated with a change in vegetation cover, which reacts most quickly to changes in the environment. The relevance of the topic is determined by the scarce number of large-scale studies of soil cover and plant communities in the Bulgarian mountains over the past two decades. The selected area - the northern macroslope of Rila, has been the subject of several similar studies (Rusakova, 2001a, 2001b, 2001c), which are a snapshot of the state of landscapes and their components. Konteva et al. (2001) also conducted landscape research in the subalpine and alpine belts of Northwestern Rila, which are also reflected in a monography by Velchev et al., 2011. Unlike other geocomponents, soil associations with their corresponding plant communities remain less studied. Such research is fundamental to the development of physical geography in Bulgaria.

The diversity of Cambisols is diagnosed based on the ratio between humic and fulvic acids. Antonov (2003) emphasizes this problem, and Filcheva (2014) deepens these studies in Bulgaria. In this publication, qualitatively new data on the ratio of organic matter in soil catenas are presented, and for the first time an attempt is made to link these data to specific plant communities. Through the relationship between humic and fulvic acids, the interaction of the vegetation involved in soil formation processes has been established. The obtained data characterize the type of humus and can find application in the diagnosis and classification of Cambisols in the Bulgarian mountains.

2. Materials and Methods

The preparatory activities were related to the discussion of the specific commitments of the participants in the project, specification of the methods for field work and selection of representative points for research of mountain-meadow and brown forest soils, as well as planning of the field work.

Our main scientific activities were conducted in field and in the laboratory. We got acquainted in advance with the existing geological, geomorphological, soil and other maps of the study area.

The main field work was carried out in July 2021, and during the autumn period additional observations and descriptions of plant sites were made in order to verify the data obtained during the summer period.

During the field stage, the team tried to map as many zonal and azonal soils as possible. Samples of the surface organic horizon were tested in 8 key sites to diagnose the subspecies diversity of brown forest soils (Cambisols). An analysis of the fractional composition of organic matter (ratio of humic acids **Ch** to fulvic acids **Cf**) was performed according to BDS of the collected samples from different profiles and genetic soil horizons in the Central Research Laboratory of IPAPR "Nikola Pushkarov". The qualitative composition of humus in different soils is determined by the ratio of the content of humic acids to that of fulvic acids. Fulvic acids predominate in soils formed under forest vegetation, while humic acids are associated with presence of grass vegetation. The higher amount of Cf compared to Ch indicates a weakly expressed humification process in cold and humid climates and a greater participation of forest vegetation.

All species of higher plants were noted in all 8 test sites (Fig. 1). For each species, its abundance and coverage were assessed using the seven-point Braun-Blanquet scale (Braun-Blanquet 1965, Westhoff & van der Maarel 1973).

The key (test) sites were set up in homogeneous and representative for the plant communities plots, and the aim was to avoid descriptions in sites that would not reveal the main characteristics of the studied soil-plant sites. The shape of the sites is square and their size is in accordance with the sizes recommended by Chytrý & Otýpková (2003) depending on the type of vegetation:

For most types of grass vegetation (which includes grass vegetation from the temperate zone) $- 16 \text{ m}^2$,

· For bush vegetation – 64 m² and

· For forest vegetation - 225 m².

A passport containing the results of the fractional composition of humus and vegetation has been drawn up for each surveyed area.

The team gathered the necessary information about the current state of soil and plant diversity on the northern slopes (N, NW, NE) of the Rila Mountain.

The following results were achieved:

- studies in 8 sites located on slopes with different aspects are presented.

- forest species, shrubs and grasses were identified.

- a chemical analysis in the Central Laboratory of the Institute of Soil Science, Agrotechnology and Plant Protection "Nikola Pushkarov" have been undertaken to determine the content and composition of soil organic matter which allowed the characterization of the material composition of humus/organic carbon. This was accomplished according to Kononova's method (1963) following the standards in Bulgaria (protocol 151/20.09.2021).

- passports have been drawn up including comparable geographical, soil and plant observations. With regard to vegetation, only the predominant species will be published.

Four soil and vegetation sites in Northwestern Rila, one in Central Rila and three in Eastern Rila were mapped (Fig. 1).

3. Case study area

Rila is located in southwestern Bulgaria and represents the highest mountain range in the country. The highest peak is Musala (2925 m a.s.l.). The mountain is a horst, which is divided into four parts. Magmatic and metamorphic rocks are the most abundant. Climate is typical Alpine and the mountain is the source of major Bulgarian rivers, such as Iskar, Maritsa and Mesta. Soils are mainly Cambisols and Umbrosols. A number of deciduous and coniferous species represent tree vegetation.

4. Results

The first site (Passport 1) is located in Northwestern Rila. The terrain has a northern exposition, with predominant coniferous species in the tree floor on Albic Cambisols.

Site 21 is located in the Basin of Dzherman River, where there is an equal participation of common spruce and common fir. They are mixed with beech and the ratio between the organic carbon of humic and that of fulvic acids in the surface horizon (Ch/Cf) is 0.78.

The second site (Passport 2) is in the Djubrena Valley, a right tributary of the German River. Its watershed drains parts of Verila, the Klisura saddle and northeastern territories of Northwestern Rila. The tree layer is represented by deciduous species. The map represents a nice example of the territorial trinity: changing slope, metamorphites and cambisols, the main criterion for the establishment of soil catena, represented in the works of G. Milne (1935) from the 30's of last century.

The species composition of the tree floor is represented (passport 2, site.23) by 45% abundance of common beech, 35% of common hornbeam. These communities can be discovered in the lower part of the slope. The quantitative data for the material composition of the humus is 0.69, despite the fact that in the previous site (Passport 1) the vegetation was mixed, and here it is entirely deciduous.

The third site (Passport 3) is located in the Malyovitsa Valley (NW Rila), with a prevalance of coniferous tree species.

The profile in the valley of the Maliovitsa river (at 1738 m), has a depth of 75-80 cm and a small thickness of the humus horizon. In the species composition of the vegetation, Scots pine and Balkan



Figure 1. Location of sampled key sites in Rila Mountain

pine are present. The result of the laboratory analysis of the soil sample showed that fulvic acids predominate, which defines the soils as Dystric Cambisols.

Key site 26 (Passport 4) is located in the Cherni Iskar Valley and represents typical for the area shrubland and grassland vegetation on Humic Cambisols. The value of the Ch/Cf ratio on the terrace of the Cherni Iskar River turned out to be greater. After the destruction of forests in the land above the village of Govedartsi (Passport 4, section 26) the native forest vegetation was changed to herbaceous communities due to the process of anthropogenization. Therefore the ratio of Ch/Cf is 1.61.

The fifth site (Passport 5) is in the Iskar valley with an altitude of 1465 meters. The soils are characterized by a profile depth of 40 to 60-70 cm, low thickness of the humus horizon - with too little organic matter, high acidity, low humus reserve, low sorbtion capacity, low saturation with bases, good drainage, diverse hydro-thermal regime. Beech forests are predominant. The forest litter is between 3-8 cm. Gneiss foundation and slopes with different exposures are a prerequisite for a significant surface water runoff. The Ch/Cf ratio is close to 1, which is a diagnostic feature of Dystric Cambisols. The ratio is an indicator of the relatively equal share of humic acids (Ch/Cf < 1).

The first site in Yadenitsa River valley was with an inclination of 25° (Passport 6). Deciduous forests on Albic Cambisols occur.

The same ratio of humic to fulvic acids was found here as in plot 24 (Passport 3), regardless of the differences in plant cover. The vegetation in plot 28 resembles plot 27, where *Fagus sylvatica* dominates, and the abundance (total projective cover) is about 95%. A very large difference in slope gradient is observed between the two sections.

The seventh site (Passport 7) was located in Eastern Rila, nearby Belmeken dam. The site is covered by shrubland and grassland vegetation with the prevalence of *Pinus mugo* on Orthic Umbrosols. Passport 7 resembles the vegetation in Passport 4 with a projective coverage of 90%, due to the lack of a tree floor. Despite these similarities, the Ch/Cf ratio is very different. In site 31 it is 0.85 or twice lower compared to passport 4.

The eighth site (Passport 8) is along the Bistritsa River. We chose a representative section along the upper border at the foot of the Dolnobanska valley in the land of the village of Sveti Spas. The tree layer is dominated by deciduous species. At this site, there is a participation of hornbeam (70%), beech (10%), as well as larch and maple. In the shrub layer, we found the same presence of *Corylus avellana* and *Carpinus betulus*, although with a different abundance. Soils are Albic Cambisols with Ch/Cf < 1 ratio. The similar species composition and the humate-fulvate type of humus formation diagnosed by value higher by 0.13 (Passport 6, site 28) points moves soils to the group of isohumus unsaturated soils.



Site number: 21 Coordinates: 42°14.8087 N, 23°18.6517 E Altitude: 1590 m Aspect: N Slope inclination: 12° Soils: Albic Cambisols Ch/ Cf 0,78 Vegetation: Total projective cover- 80% Tree layer: *Picea abies, Abies alba, Fagus sylvatica* Shrub layer: *Vaccinium myrtillus, Rubus idaeus* Herb layer: *Lathyrus niger, Physospermum cornubiense, Pteridium aquilinum*

Passport 1.



Site number: 23 Coordinates: 42°19.9144 N, 23°20.3237 E Altitude: 915 m Aspect: NE Slope inclination: 15° Soil - Albic Cambisols Ch/ Cf 0,69 Vegetation: Total projective cover- 95% Tree layer: *Fagus sylvatica, Carpinus betulus, Acer pseudoplatanus* Shrub layer: *Fagus sylvatica, Carpinus betulus, Picea abies* Herb layer: *Pteridium aquilinum, Lathyrus niger, Galium odoratum, Cardamine bulbifera, Lamium maculatum*

Passport 2.



Site number: 24

Coordinates: 42°12.4508 N, 23°23.2208 E Altitude: 1738 m Aspect: N Slope inclination: 10° Soil - Albic Cambisols **Ch/ Cf** 0,78 Vegetation: Total projective cover - 80% Tree layer: *Pinus sylvestris, Pinus peuce, Betula pendula, Abies alba, Picea abies* Shrub layer: *Vaccinium myrtillus, Vaccinium uliginosum, Vaccinium vitis-idaea, Juniperus sibirica, Arctostaphyllus uva-ursi* Herb layer: *Pteridium aquilinum, Lapsana communis, Fragaria viridis, Cruciata glabra*

Passport 3.



Site number: 26

Coordinates: 42°15.2630 N, 23°27.3976 E Altitude: 1184 m Aspect: N Slope inclination: 2° Soils - Humic Cambisols **Ch/ Cf** 1,61 Vegetation: Total projective cover: 90% Shrub layer: *Juniperus communis, Pinus sylvestris, Juniperus sibirica, Rosa canina* Herb layer: *Taraxacum officinalis, Plantago lanceolata, Achillea millefolium, Juncus tenuis, Festuca pratensis, Poa pratensis, Cichorium intybus, Geranium phaeum, Fragaria viridis, Medicago falcata*

Passport 4.



Site number: 27 Coordinates: 42°15.5012 N, 23°34.6088 E Altitude: 1465 m Aspect: NE Slope inclination: 15° Soils - Albic Cambisols Ch/Cf 0,94 Vegetation: Total projective cover - 95% Tree layer: Fagus sylvatica, Picea abies, Abies alba Shrub layer: Abies alba, Picea abies, Vaccinium myrtillus Herb layer: Sanicula europaea, Galium odoratum, Cardamine bulbifera, Lamium maculatum, Pteridium aquilinum, Physospermum cornubiense, Oxalis acetosella

Passport 5.



Site number: 28

Coordinates: 42°08.7008 N, 23°57.5980 E Altitude: 829 m Aspect: NE Slope inclination: 25° Soils - Albic Cambisols **Ch/ Cf** 0,78 Vegetation: Total projective cover - 95% Tree layer: *Fagus sylvatica, Carpinus betulus, Tilia platyphyllos* Shrub layer: *Corylus avellana, Carpinus betulus, Sambucus nigra, Fraxinus ornus, Acer pseudoplatanus* Herb layer: *Luzula luzuloides, Pteridium aquilinum, Lathyrus niger, Lamium maculatum*

Passport 6.

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Site number: 31 Coordinates: 42°09.9859 N, 23°49.4664 E Altitude: 2041 m Aspect: NW Slope inclination: 5° Ch/Cf 0,85 Soils - Orthic Umbrosols Vegetation: Total projective cover - 90% Shrub layer: *Pinus mugo, Epilobium angustifolium, Rubus idaeus* Herb layer: *Sanicula europaea, Hypericum perforatum, Viola tricolor, Campanula lanata*

Passport 7.



Site number: 34 Coordinates: 42°16.5651 N, 23°43.8484 E Altitude: 851 m Aspect: NE Slope inclination: 15° Soils - Albic Cambisols Ch/ Cf 0,91 Vegetation: Total projective cover: 100% Tree layer: Carpinus betulus, Fagus sylvatica, Fraxinus ornus, Acer campestre Shrub layer: Corylus avellana, Rosa canina, Carpinus betulus, Quercus dalechampii Herb layer: Lamium maculatum, Lathyrus niger, Pulmonaria officinalis, Physospermum cornubiense, Lapsana communis

Passport 8.

5. Conclusion

In summary, our observations on the eight sites revealed the main characteristics of the studied catenas with significant qualitative composition of soil organic matter. We highlighted specific differences in the Northwestern and Eastern Rila.

The results show a distribution of Albic Cambisols soils, which contain humate-fulvate type of humus in the surface horizon of the soil, as following: three areas between 829 and 915 meters that are under deciduous vegetation and three areas between 915 and 1738 m under mixed vegetation. Humic Cambisols were tested at 1184 meters under shrub and herbaceous vegetation. Similar vegetation on Orthic Umbrosols, but with a Ch/Cf 0.85 ratio between humic and fulvic acids in the surface horizon, was diagnosed at 2041 m above the Belmeken dam. The catena in Eastern Rila includes Orthic Umbrosols and Albic Cambisols under deciduous vegetation. The analysis of the results of the fractional composition defines the soils as unsaturated mountain-meadow, turf (Orthic Umbrosols) and unsaturated light brown mountain-forest (Albic Cambisols) with ratio Ch / Cf <1 under shrub vegetation and vegetation with deciduous trees, respectively.

In Northwestern Rila there is an alternation of soils depending on the fractional composition of humus as follows: Humic Cambisols under coniferous shrubs and grasses and Albic Cambisols under mixed vegetation.

The ratio between fulvic and humic acids is associated with the dominant vegetation in the northern macroslope of Rila Mountain and it changes under the influence of natural and anthropogenic factors. Humic acids are associated with the presence of herbaceous vegetation, whereas fulvic acids are predominant in soils formed under forest vergetation. The obtained data on the relationship between the composition of humic acids and the type of vegetation is a prerequisite for the diagnosis and classification of mountain zonal soils.

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