Главные редакторы: Виктор Г. Сычёв и Лотар Мюллер

НОВЫЕ МЕТОДЫ И РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЛАНДШАФТОВ В ЕВРОПЕ, ЦЕНТРАЛЬНОЙ АЗИИ И СИБИРИ

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Коллектив авторов и редакторов под руководством В.А. Романенкова (Москва), А.Х. Шеуджена (Краснодар), Л. Мюллера (Мюнхеберг).

Главные редакторы: Лотар Мюллер (Лейбниц центр агроландшафтных исследований, Мюнхеберг, Германия) и Виктор Г. Сычёв (Всероссийский научно-исследовательский институт агрохимии им. Д.Н. Прянишникова, Москва, Россия)

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This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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ABSTRACT. Stewardship of soil organic carbon (SOC) is of paramount importance in formation and functioning of landscape. From the humus status (HS) of landscape’s soils depend forest ecosystems composition and functioning (annual productivity and litter fall). In our work the methodological principles used in evaluation of soils’ HS and the quantitative data of dominated Estonian forest soils’ HS are presented. The main attention is paid to SOC concentration, stocks and distribution in the HC, as well to soils’ humus cover (HC) fabric and types (pro humus forms). Essential are also the analyses on the role of HS in SOC cycling and its annual balance, in formation of ecosystems biodiversity and in evolving to landscape the environment protection ability. All key terms and soil names used in local level are explained as well by international ones.

KEYWORDS: humus status, forest soils, pedocentric approach, humus and soil cover, landscape, soil map

INTRODUCTION

For the material basis of a landscape is its soil cover (SC). The appearance and functioning of landscape depends besides of SC on other factors including area relief, climatic conditions and land use. Therefore, the fabric, diversity and functioning capacity of formed on natural landscapes terrestrial ecosystems depend mainly on the physical-chemical properties and watering conditions of their soils [1, 2]. The best indicator in characterizing of forest landscape’s functioning intensity is the humus status (HS) of its SC. The HS of soils may be taken as a driving force, which determines the character of processes and evolution direction of the forest landscapes.

Main aim of this overview is to elucidate the role of soils’ HS in the functioning of landscapes. The knowledge on soil organic matter (SOM) throughout flux of SC or functioning regularities are essential in the planning of ecologically sound management and protection of forest landscapes. The integrating of soils’ data into the landscape management is possible thanks to the availability (1) of large scale (1:10,000) soil maps for all Estonia and (2) of quantitative data on HS for all dominated soil types. In actual work both the methodological principles and the quantitative examples about some dominated Estonian forest soils’ HS are given [2, 3, 4].
METHODOLOGICAL PRINCIPLES AND EXPLANATION OF TERMINOLOGY

For explaining the SC role in development and functioning of forest landscapes the pedocentric approach is used (Fig.1). The HS of a soil is in principle the management character of SOM or its throughout flux via the SC. This flux begins with litter fall on or into the soil and follows by variegated processes in mutual relationships with soil living, liqued, gaseous and solid phases, until to its stabilization or/and total mineralization and elimination from the SC. The terms used in the quantitative characterization of HS are (1) **SC or solum** which embraces the superficial landscape layer influenced by soil forming process and consists of humus cover (HC) and subsoil (SS), and (2) **HC or topsoil or epipedon** which encompasses the most active superficial part of SC via which the dominant part of soil organic carbon (SOC) cycling takes place. The HC consists of the forest floor, humus or raw humus and peat horizons and is closely coupled with plant cover. SS consists of the eluvial and illuvial horizons.

![Diagram](image)

Figure 1 – Soil cover of the landscape is an intermedium between non-living (geo) and living (bio) compartments: Pedodiversity depends much on geodiversity but determines in turn the outlines of biodiversity.

Treating of SC on the basis large scale soil maps (1:10,000) needs the using of detail level classification taxa as (1) **soil species** which is the taxon of Estonian soil classification (ESC) identified by soil forming processes, (2) **soil variety** - taxon of ESC identified by soil species’ texture and (3) **soil association** - an assemblage of two or more soil species (or varieties) within a designated soil contour, recurring in different patterns across the landscape.

ORIGIN OF USED DATA AND OUTLINES OF METHODS

The quantitative data of soils’ HS originate mainly from the soil profile horizons database (DB) *Pedon* and HS research transect DB *Catena* created by us. The main parameters of soils’ HS are the thickness and morphology of soil horizons, SOC concentration (g kg⁻¹), stocks (Mg ha⁻¹) and annual cycling (Mg ha⁻¹ yr⁻¹). The SOC stocks are calculated on the basis of the SOC concentrations and bulk densities of corresponding soil horizons. The volume of the coarse soil fractions were determined during the field research. The content of fine-earth (ø <1.0 mm) in soil samples was determined in the laboratory by sieving, but the particle size distribution by using the pipette method of Kachinsky. SOC concentration was determined by wet digestion of carbon with acid dichromate. In calculation of SOM in mineral soils the coefficient 1.72, but of peaty soils and forest floors 2.00 was used. The soil names given in the national DB by ESC were converted into World Reference Base (WRB) soil classification system. In addition to our experimental data the materials published on HS and productivity of mineral and peat soils of Estonia and on peat soils of Poland were used.

OVERVIEW ON LAND USE AND OF CLIMATIC AND PEDO-ECOLOGICAL CONDITIONS

To the natural area of Estonia, which is located in mild and wet pedo-climatic conditions, mainly the mixed forests are characteristic. As a result of intensified agricultural activity during last two centuries the most productive areas of Estonia (soils suitable for crop cultivation and grasslands) have been turned into arable, pastured or hay-lands (Fig. 2).
The main part of parent materials of soils is derived here from glacial and aquaglacial Quaternary deposits. For the parent material of half mineral soils are Pleistocene tills. The re-worked from tills glaciofluvial, glaciolacustrine, alluvial and aeolian sediments are distributed alternatively with tills. Estonian forested landscapes’ SC is typical to north-eastern Europe, where the Histosols (37%) and Gleysols (ca 36%) and are dominated. Among Histosols the sapric and fibric soil subdivisions in fens and bogs are dominating. From the Gleysols a half have eutric (calcareous) and a quarter – dystric properties. The share of automorphic mineral soils is only 24.3% of forest, from which the subdivisions of Retisols (7.9%), Cambisols (6.5%) and Podzols (6.0%) are dominating. The texture and moisture conditions of forested landscapes are characterized on Fig. 3. The landscape is shown in the photos of the Appendix.

**EXAMPLES ABOUT SOME GENERALIZED RESULTS AND POSSIBILITIES FOR FURTHER DELIBERATIONS**

Depending on soil type and land use the soils’ HS quantitative characteristics are quite different in different SC layers (Table 1). Besides of simple soils HS characterization by SOC (SOM) content, vertical distribution in SC and horizontal pattern is possible to develop lot of pedocentric landscapes researches as (1) to present generalized data on humus balances (Fig. 4) and potential productivity of dominating soils [4, 5], (2) to present the HS data by soil species and their associations, by forest site types, by humus cover types [6] or by landscape regions [1], (3) to analyze the role of peatlands in landscapes for elucidating a reasonable equilibrium between their using and protection [7], and oth.
Table 1. Weighted mean data on SOC retention capacity (Mg ha⁻¹) of forested lands’ soil cover.

<table>
<thead>
<tr>
<th>Land use, layerᵃ⁾</th>
<th>Automorphic mineral soils</th>
<th>Hydromorphic mineral soils</th>
<th>Wetland organic soils</th>
<th>Weighted means of all soil groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest land, SC</td>
<td>72.5</td>
<td>130.3</td>
<td>237.9</td>
<td>156.0</td>
</tr>
<tr>
<td>Forest land, HC</td>
<td>47.6</td>
<td>97.0</td>
<td>108.1</td>
<td>89.1</td>
</tr>
<tr>
<td>Forest land, SS</td>
<td>24.9</td>
<td>33.3</td>
<td>129.8</td>
<td>66.9</td>
</tr>
</tbody>
</table>

ᵃ⁾ Weighted (by area) means; b) Abbreviations: SC – soil cover; HC – humus cover, and SS – subsoil.

Our researches insist that SC is a determining factor in the development of plant cover and its diversity. The pedodiversity may be caused by soil texture variations (from sand to clay), mineralogical and chemical composition, calcareousness and acidity. The pattern of SC and its diversity are induced by area geo-diversity and hydrological conditions. For better understanding of mutual influences of SC and plant cover, the feedback influences of their main components (soil, plant) functioning should be studied at the ecosystem level, on typical-to-region soil types and management conditions. The annual productivity of natural ecosystems on well-drained soil depends mainly on clay and SOM content and stock in the soil profile, but on wet soils from watering character [5]. The maximum functioning activity of an ecosystem is observed in the presence of plant cover, which is optimal to soil properties.

**CONCLUSIONS**

1. The pedodiversity of the landscape is an abiotic base for formation of optimal (specific to soil type) plant cover biodiversity. The ecologically sound matching of soil and plant covers is of pivotal importance in the reaching of sustainable ecosystem functioning and of a good environmental status of ambient area.

2. HS of natural forest landscapes has a determinative role in the formation of plant cover composition, productivity and diversity. Therefore the awareness on the composition and properties of HC types (pro humus forms) and their relationship with plant cover and SOM decomposition potentiality are the basis of ecologically proper and sustainable management of land (soil) resources.

3. Comparative analysis of soil-plant mutual relationships on the background of pedo-ecological conditions revealed that (1) the biodiversity of an ecosystem depends on soil properties, being therefore a
soil type-specific feature, and (2) the type of HC is a good ecological indicator in characterizing outlines of the biological turnover between soil and plant.

REFERENCES


**Appendix, Photo 1.** Meeni-kunnu, Estonia. Pine forest of Rhodococcum (on higher areas) and Myrtillus (on lower areas) site type on typical Podzols; by WRB for the dominating soils of the higher areas are Albic Carbic Podzols (Arenic), but of the lower Ortsteinic Albic Gleyic Podzols (Arenic). (Photo K. Kauer)

**Appendix, Photo 2.** Karula, Estonia. Forest landscape with coniferous and mixed forests on the Karula Height; quaternary cover here is formed in late glacial period as an edge formation composed of morainal hills, adjoining mounds and paludified depressions; to this landscape is characteristic a high degree of pedodiversity. (Photo K. Kauer)