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Short communication

Dynamics of annual falling debris decomposition and forest floor accumulation

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ABSTRACT

The level of forest ecosystems' productivity and functioning character may be to a great extent explained by its soil cover properties and carbon cycling peculiarity. The fabric and properties of forest ecosystems' topsoil (designated in Estonia as "humus cover type", but by Humusica as "humus form") depends on the dynamics of annual falling debris (AFD) accumulation-decomposition in the forest floor (FF). For characterization of AFD dynamics or its flow throughout the FF into soil or atmosphere, the mean perennial graphical models were used. The comparative analysis of AFD flow and FF formation dynamics was carried out in four forest ecosystems of the temperate zone of the Atlantic-continental region. The studied forest stands were by their layers structure and interrelationships of the system "plant-soil" in stabilized stage. The used data originated from our previous researches on the dynamics of AFD by different fractions and of fractional composition of the FF. The flow of mean aboveground AFD throughout the FF depends on the quantity and dynamics of the AFD, on fractional composition of AFD and on pedo-ecological conditions of decomposition. The lowest decomposition rate was obtained in fresh moder humus cover (by Humusica Hemi- and/or Eumoder) on Glossic Retisols, but the highest, in fresh forest-mull humus cover (by Humusica Eu- and/or Mesomull) formed on Calcaric Cambisols. Due to the low decomposition rate in ecosystems formed on Glossic Retisols, only readily decomposable parts (herbs, leaves) disappear quickly from the newly formed FF. The more resistant parts of AFD accumulate for many years in a half-decomposed state on the surface of mineral soils (or on A-horizon), forming a multi-layered FF. The superficial density of phytogenic origin FF dry mass on Glossic Retisols is in limits of 21.5–24.5 Mg ha^{-1}, whereas the mean accumulation coefficient of FF formation varies from 3.35 to 3.44. The mean amount of phytogenic FF on Calcaric Cambisols with mixed spruce forest was 7.6 Mg ha^{-1} and in the oak forest 3.2 Mg ha-1. The accumulation coefficient of FF formation in conditions of fresh forest-mull type humus cover was in the mixed spruce forest 1.50 and in the pure oak forest 0.66. The most important factors of AFD decomposition-mineralization are biological activity and agrochemical status of soil.

1. Introduction

The productivity of ecosystems and the formation of forest floor (FF) depend on the dynamics of annual falling debris (AFD) accumulation-decomposition character. AFD consists of plant remains, eliminated from the aboveground living vegetation during one year. AFD accumulates to the surface of topsoil, forming there the O-horizon, which is a part of the whole humus profile or humipedon (Humusica 1, 2017b). From the AFD and FF (or O-horizon) formation dynamics depend as well the fabric and properties of whole humus profile, which is by Estonian terminology soil humus cover, but by the terminology of Humusica humus form (Humusica 1, 2017c). For the quantitative characterization of AFD decomposition dynamics or it flow through the FF into the soil or atmosphere, the mean perennial graphical models were used. These models allow also to explain the dynamics of new soil organic matter accumulation into the O-horizon.

The comparative analysis of the dynamics of AFD flow and FF formation was carried out in four forest ecosystems (Table 1) located in the temperate zone of the Atlantic-continental region i.e. in the pedo-ecological conditions of Estonia, characterized by warm summers and mild winters. The forest stands studied were in the premature or mature stage, with stand stock density 0.6-0.9 and therefore their layers' structure and interrelationships between plant cover and soils were stabilized (Table 2). The data presented here originated from our previous publications, in which more profound characterization of these data is given (Kõlli, 1975, 1977, 1980, 1986).

2. Results and discussion

The flow of mean aboveground AFD through the FF depends, (i) on

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Table 1
General characterization of studied forest ecosystems.

No	Soils by WRB – 2015[a]	Forest site type[b]	Humus cover type[b]	Composition of forest stand[c]
1.	Glossic Retisols	Oxalis	fresh moder	10S
2.	Glossic Retisols	Oxalis	fresh moder	9P1S
3.	Calcaric Cambisols	Hepatica	fresh forest-mull	9S1OB + P
4.	Calcaric Cambisols	Hepatica	fresh forest-mull	10O + B

[a] By IUSS Working Group WRB, 2015.
[b] By local (Estonian) classifications.
[c] S – spruce, P – pine, O – oak and B – birch.

Table 2
Quantitative characterization of studied ecosystems.

Characteristic	Unit	Number of ecosystem			
		1.	2.	3.	4.
Mean age of the stand	year	80	73	84	200
Total phytomass of ecosystem	Mg ha^{-1}	308	376	253	197
Mean annual aboveground falling debris	Mg ha^{-1} yr^{-1}	6.78	5.12	5.06	4.88
Stock of phytogenic forest floor	Mg ha^{-1}	22.7	17.6	7.6	3.2
Stock of total forest floor	Mg ha^{-1}	32.9	25.4	15.4	4.6
C:N ratio – of forest floor/A-horizon	ratio	36/11	37/10	29/11	20/10
Saturation stage of A-horizon	%	38	47	67	80

quantity (Table 2) and the dynamics of falling debris (Kõlli, 1975), (ii) on pedo-ecological conditions of debris decomposition (Table 2), and (iii) on fractional composition of falling debris (Kõlli, 1980). The relative decomposition rates of different falling debris fractions (leaves, needles, twigs, etc.) are varied in a great extent depending on pedo-ecological conditions (Kõlli, 1977).

The longest through flow time or the lowest decomposition rate of AFD was obtained in *fresh moder* humus cover, which have formed on *Glossic Retisols* (Figs. 1 and 2). *Fresh moder* type humus covers of ecosystems No 1 and 2 (Tables 1 and 2) have formed under the influence of *Oxalis* type spruce and pine forest with well-developed green moss layers and poor understory.

The smallest mean through flow time or the highest decomposition rate of AFD was obtained in *fresh forest-mull* humus cover, which has formed on *Calcaric Cambisols* under the influence of *Hepatica* type oak forest with well-developed herbaceous and hazelnut-rich understory (Figs. 1 and 3).

Due to the low decomposition rate of total falling debris in ecosystem 1 (Fig. 1, curves 1 and 2), only the readily decomposable parts

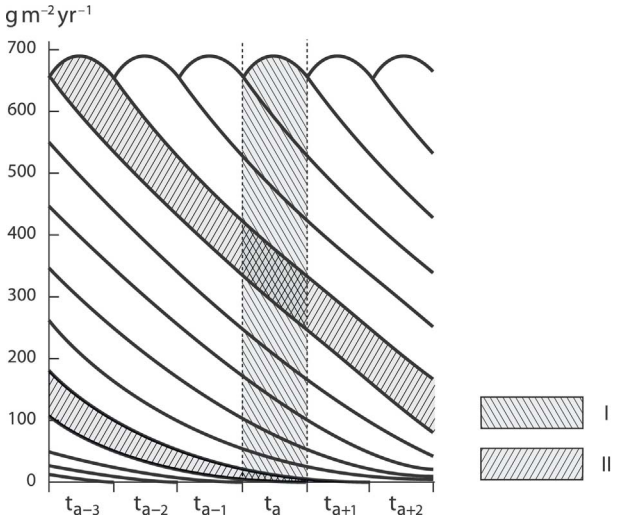

Fig. 2. Graphical model of annual debris decomposition in ecosystem No 1 (see Table 1). Belts: I – Distribution of annual falling debris by the age of its constituents at a certain year (ta) and II – decomposition intensity of the mean long period annual forest debris.

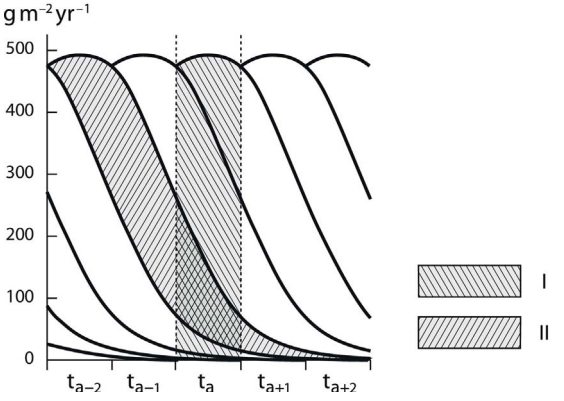

Fig. 3. Graphical model of annual debris decomposition in ecosystem No 4 (see Table 1). Belts: I – Distribution of annual falling debris by the age of its constituents at a certain year (ta) and II – decomposition intensity of the mean long period annual forest debris.

(herbs, leaves) have disappeared from the accumulated AFD or from newly formed FF. As a rule, in this process, the more resistant parts of the annual debris accumulate for many years in a half-decomposed state on the surface of mineral soils (or on A-horizon), forming there a multi-layered FF or O-horizon, with clearly distinguished sub-horizons (OL, OF and OH).

The superficial density of total phytogenic origin FF dry mass of *Oxalis* type spruce forests on *Glossic Retisols* is in limits of 215–245 g per m^2 or 21.5–24.5 Mg ha^{-1}. The mean accumulation coefficients of FF

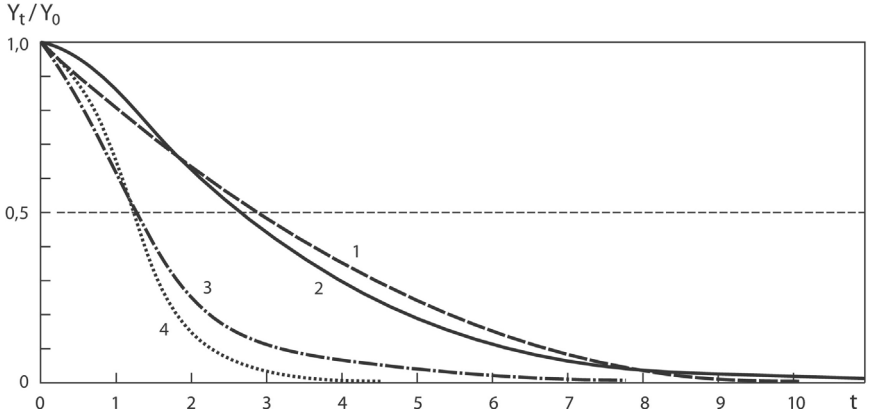

Fig. 1. Decomposition dynamics of total aboveground annual falling debris.
1–4–decomposition curves of aboveground annual falling debris of forest ecosystems, which general characterization is given in Table 1. On the figure Yt is the retained part of total debris at a certain time, Y0–initial annual debris stock, Yt/Y0–relative decomposition rate and t – time in years.