

# MORPHOLOGICAL CHARACTERIZATION OF HUMUS FORMS IN COASTAL DUNE SYSTEMS: EXPERIENCE FROM THE FLEMISH COAST AND NORTHWEST FRANCE

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## ABSTRACT

Humus profiles of dune soils on 46 sites along the Flemish coast and in north-west France were classified according to three classification systems (Delecour, 1980; Green et al., 1993 and Jabiol et al., 1995). These classification systems are not well adapted to young ecosystems on almost pure sand. Problems arose in the keys themselves and in the terminology and criteria which are used to classify the soils.

## Introduction

Dune soils are characterized by a shallow available soil volume for rooting (Ampe and Langohr, 1993) and a low nutrient and water supply. The presence of organic horizons is therefore of great importance to ecosystem dynamics, and a workable, comprehensive classification of humus form is needed.

The humus profiles studied are in dune areas along the Flemish coast and in north-west France. The sites are imperfectly to well drained, situated on a calcareous substratum, and vary in vegetation cover from almost bare sand to forest, including sites under grasses and shrubs. On the Flemish coast, 12 profiles were investigated from the Domeinbos Klemskerke-Vlissegem-Wenduine (Baes, 1997) and 4 from the Hannecart forest. In the Réserve biologique domaniale de la côte d'Opale (Merlimont, northwest France) 30 sites were investigated (Ampe, 1998).

The aim of the study is to test 3 published classification systems for humus profiles (Delecour, 1980; Green et al., 1993 and Jabiol et al., 1995).

## Methodology

The organic horizons of the 46 sites were described according to the guidelines of

Green et al. (1993). The following factors are used for description: moisture status, colour, fabric including structure, texture and character, roots, soil fauna and vegetation.

Thirty-eight sites were sampled by using a stainless steel cylinder (25cm diameter and 20cm long) which was hammered into the soil. The sample was separated horizon by horizon and the procedure was repeated two or three times at each site. The subsites were sampled to show the amount of variation in the humus profiles.

The humus type was determined for all 46 sites according to the three classification systems.

## The Classification Systems

The main criteria for classifying humus types, in imperfectly to well drained conditions, defined at the highest level, i.e. mull – moder – mor, are summarized in Table 1. The approach in the three classification systems is substantially different.

The classification system of Delecour (1980) distinguishes between forest and herbaceous formations at the start of the key. For the forest systems the mull and moder/mor humus types are distinguished on the basis of the morphology of the holorganic layer, which should be composed of either a mainly thin (thickness is not specified) L horizon or of an L, F and H horizon respectively (the holorganic horizon is the organic layers of the humus profile: the L, F and H horizons for well to imperfectly drained soils and the O horizon for the poorly drained soils). The distinction between moder and mor is made on the basis of the thickness of the holorganic horizons (greater or less than 10cm). Mulls are further subdivided on the occurrence of mottling, reaction with HCl or pH of the A horizon. Moders are subdivided on the relative proportion of the F and H horizon, the type of substratum, effervescence with HCl and structure of the A horizon. Within the mors, humus forms are differentiated upon the relative proportions of the F and H horizons. For the herbaceous systems only the mull and mor types exist. Mulls are distinguished from the mors on the basis of the distinctness of the boundary between the holorganic horizons and the A horizon, and the structure of the A horizon, and although not mentioned explicitly, absence or presence of the H horizon. In the mulls, subdivisions are made according to thickness of the L and F horizons and the thickness and structure of the A horizon. The differentiating criteria in the mors are thickness of the L and F horizon, structure of the A horizon sequence within the holorganic horizons and the root morphology.

In the system of Green et al. (1993) the first criterion used is the combined thickness of the F+H horizons. Then within the orders of the mors and moders, the type of F horizon (mycogenous, zoogenous or an intergrade between myco- and zoogenous) determines the group. In the mull order the group is determined by the type of A horizon (rhizogenous or zoogenous).

The system of Jabiol et al. (1995), which includes some of the concepts of Delecour, has the type of A horizon, the boundary between the holorganic and mineral horizons

Table 1. Criteria (simplified – relevant for dune soils) for the main orders for well to imperfectly drained sites (horizon symbols as they are used in the respective classification systems)

	Delecour (1980)	Green et al. (1993)	Jabiol et al. (1995)
<b>Mull</b>	<p>Forest:</p> <ul style="list-style-type: none"> <li>• absence or very thin Ol, Of, Oh</li> </ul> <p>Herbs:</p> <ul style="list-style-type: none"> <li>• gradual transition between ecto- and endorganic horizons</li> <li>• Ah de 'complexation'</li> </ul>	<p>F+H ≤ 2cm with Ah &gt; 2cm</p>	<ul style="list-style-type: none"> <li>• A de 'biomacrostructuré', horizon with crumb structure</li> <li>• discontinuity between OL, OF, OH and A horizon</li> </ul>
<b>Moder</b>	<p>Forest:</p> <ul style="list-style-type: none"> <li>• Ol+Of+Oh horizons &lt; 10cm thick</li> <li>• Ah de 'diffusion'</li> <li>• transition 'OAh'</li> </ul> <p>Herbs:</p> <ul style="list-style-type: none"> <li>• not used</li> </ul>	<p>F+H &gt; 2cm or F+H ≤ 2cm if Ah &lt; 2cm</p> <p>And</p> <p>F is zoogenous and/or an intergrade between zoo- and mycogenous</p>	<ul style="list-style-type: none"> <li>• A horizon of type 'juxtaposition' – pepper and salt</li> <li>• gradual transition from OL, OF, OH and A horizons</li> <li>• horizationation of OL-OF-A or OL-OF-OH-A</li> </ul>
<b>Mor</b>	<p>Forest:</p> <ul style="list-style-type: none"> <li>• Ol+Of+Oh horizons &gt; 10cm thick</li> <li>• no 'OAh' horizon</li> </ul> <p>Herbs:</p> <ul style="list-style-type: none"> <li>• abrupt boundary between ecto- and endorganic horizons</li> <li>• no Ah de 'complexation'</li> </ul>	<p>F+H &gt; 2cm or F+H ≤ 2cm if Ah &lt; 2cm</p> <p>And</p> <p>F is mycogenous</p>	<ul style="list-style-type: none"> <li>• OL, OF and OH horizon are thick</li> <li>• abrupt boundary between OL, OF, OH and mineral horizon</li> <li>• in the mineral horizon: organic matter de 'diffusion'</li> </ul>

and the horizon sequence as diagnostic criteria. Mulls are characterized by an A horizon with crumb structure and a clear boundary between the L, (F) and A horizons. They are further subdivided according to the thickness and type of L horizon and whether or not the F horizon is present. The moders have an A horizon with the pepper and salt morphology (*A de 'juxtaposition'* – the bleached sand particles occur next to the particles of organic matter), a more gradual limit between L, F, H and A horizons and a horizon sequence of L, F, (H) and A horizon. The moders are subdivided according to the thickness of the F and H horizon and the structure of the A. Mors have thick L, F and H horizons and an abrupt boundary between the holorganic and mineral horizons.

## Results

Table 2 provides an example of 6 sites that have been classified according to the three systems. For a total of 46 sites, the three systems classify only 24 sites as the same type at the highest level, i.e. mull–moder–mor. If we compare the systems in pairs then the agreement between systems is greater: Delecour and Green 32, Delecour and Jabiol 30 and Green and Jabiol 31. Discrepancies occur between mull/moder and moder/mor.

## Discussion and Conclusions

When applying these three classification systems it must be remembered that they were originally designed for forest systems. Delecour (1980) studied the beech forests of the Ardennes (Belgium). The system of Green et al. (1993) is based on existing classifications in use in North America, Great Britain and Europe. The background of this system is again forestry, but the classification is aimed at use in a wider range of ecosystems. Jabiol et al. (1995) state that their proposed system should be applied to forests.

Our testing clearly demonstrated that the classification systems are not well suited to young ecosystems on almost pure, sandy soils. Problems arise in the keys themselves and in the terminology and criteria for classification.

In the key of Delecour's system a subdivision is made according to vegetation type: forest or herbs. What is the position of the shrubs and combined systems of herbs and trees or herbs and shrubs? In our testing they were considered as forest formations. This leads to very similar humus forms being classified differently. A second problem is that a thickness of L+F+H of more than 10cm is required for a mor humus type. In dune soils this 10cm proves to be a very severe criterion. Furthermore, the different humus types are not described, which makes checking of the obtained result very difficult.

One of the main problems in Green et al. (1993) is the obligatory presence of Fm (mycogenous) for mor humus type. In the mull order only 2 types are distinguished, rhizo- and vermimull. Some humus forms show neither characteristic.

In the system of Jabiol et al. (1995) there is a fundamental problem. Mulls are char-

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	Delecour (1980)	Green et al. (1993)	Jabiol et al. (1995)
<b>Mull</b>	Forest: <ul style="list-style-type: none"> <li>• absence or very thin Ol, Of, Oh</li> </ul> Herbs: <ul style="list-style-type: none"> <li>• gradual transition between ecto- and endorganic horizons</li> <li>• Ah de 'complexation'</li> </ul>	$F+H \leq 2\text{cm}$ with $Ah > 2\text{cm}$	<ul style="list-style-type: none"> <li>• A de 'biomacrostructuré', horizon with crumb structure</li> <li>• discontinuity between OL, OF, OH and A horizon</li> </ul>
<b>Moder</b>	Forest: <ul style="list-style-type: none"> <li>• Ol+Of+Oh horizons &lt; 10cm thick</li> <li>• Ah de 'diffusion'</li> <li>• transition 'OAh'</li> </ul> Herbs: <ul style="list-style-type: none"> <li>• not used</li> </ul>	$F+H > 2\text{cm}$ or $F+H \leq 2\text{cm}$ if $Ah < 2\text{cm}$ And F is zoogenous and/or an intergrade between zoo- and mycogenous	<ul style="list-style-type: none"> <li>• A horizon of type 'juxtaposition' – pepper and salt</li> <li>• gradual transition from OL, OF, OH and A horizons</li> <li>• horizonation of OL-OF-A or OL-OF-OH-A</li> </ul>
<b>Mor</b>	Forest: <ul style="list-style-type: none"> <li>• Ol+Of+Oh horizons &gt; 10cm thick</li> <li>• no 'OAh' horizon</li> </ul> Herbs: <ul style="list-style-type: none"> <li>• abrupt boundary between ecto- and endorganic horizons</li> <li>• no Ah de 'complexation'</li> </ul>	$F+H > 2\text{cm}$ or $F+H \leq 2\text{cm}$ if $Ah < 2\text{cm}$ And F is mycogenous	<ul style="list-style-type: none"> <li>• OL, OF and OH horizon are thick</li> <li>• abrupt boundary between OL, OF, OH and mineral horizon</li> <li>• in the mineral horizon: organic matter de 'diffusion'</li> </ul>

acterized by an A with a crumb structure and an intimate mixture of organic and mineral material caused by the activity of earthworms and described as the A *de 'biomacrostructuré'*. In dune soils, as soon as some decalcification takes place, the morphology of 'pepper and salt' or the A *de 'juxtaposition'* is observed. This type of horizon is, however, a characteristic of the moder humus form. Another problem is that neither moders nor mors show any crumb or micro-crumb structure; the A horizons should be massive or single-grained. However, the A horizon of the '*juxtaposition'* type with a crumb structure has been observed.

There are terminology and criteria problems in the three classification systems:

- clear definition of the diagnostic criteria, especially to distinguish L and F, is missing in the three systems;
- definition of horizon A *de 'complexation'* and A *de 'diffusion'* (Delecour) is missing;
- differentiating criteria in the keys are too vague; thickness of horizons is not specified (e.g. Delecour: *mince* [thin], *très mince* [very thin]);
- use of two criteria at one point in the key which are not always mutually exclusive (e.g. Delecour: thickness of Ah and rooting density and thickness of Ol+Of+Oh with sharpness of boundary with the mineral horizons and type of A horizon and substratum);
- clear illustrations of the diagnostic horizons such as the Fz, Fa and Fm, and the Hh, Hz and Hr, are missing (Green et al., 1993).

In the three systems little or no attention is paid to the seasonal variability in the dynamics of the organisms in the humus profile. This poses problems for measuring the thickness of the holorganic horizons and the presence of mycelia and soil fauna.

Based on the experience explained above, the following recommendations can be made:

- in the definition of the L and F a clear distinction should be made between the degree of fragmentation and the degree of mixing;
- size of fragments of needles, leaves and grasses should be specified;
- specification of description and sampling period is necessary;
- development of more precise and illustrated diagnostic criteria (thickness, sharpness, traces of biological activity) is required.

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