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Soil Profile Description and Classification (WRB-2006) of the 10 Flemish Level I Forest Plots




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Pictures on cover and inside the report by Jari Hinsch Mikkelsen (JM)

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1. Introduction

At the end of the '80s Flanders set up a forest monitoring network within the framework of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) operating under the UN/ECE Convention on Long-Range Transboundary Air Pollution. ICP Forests monitors the forest condition in Europe in cooperation with the European Commission using two different monitoring intensity levels. The first level (Level I) is based on about 6000 observation plots on a systematic transnational grid of 16 x 16 km throughout Europe. The intensive monitoring level comprises about 800 Level II plots in selected forest ecosystems in Europe. At present the Flemish network comprises 10 international Level I plots. Within the EU demonstration project 'BioSoil', Flanders made a soil inventory on its 10 Level I plots. This document reports on the soil survey which included a detailed profile pit description and soil characterisation complemented by laboratory data. The finality of this characterisation was to come to a soil classification name for the concerning plot according to the World Reference Base for Soil Resources (IUSS Working Group WRB, 2006).

BioSoil is a demonstration project covering one soil module for Level I and one for Level II as well as a biodiversity module. The overall goal of the soil module is to test the ICP Forests soil manual. The project will mainly deliver the data, which are required by the Community to contribute to the discussion concerning soil monitoring at Community level. The following specific objectives have been defined for the soil module Level I:

1. To establish an improved common European baseline of forest soils for environmental applications
2. To finalise the common European methodology for (forest) soil monitoring on the basis of the ICP Forests Manual and other relevant guidelines
3. To upgrade the quality of the existing forest soil database
4. To quantify spatial variability on the basis of information available and supplementary field experiments.
5. To detect and explain temporal changes in forest soils.
6. To improve the actual evaluation concepts, in specific by more advanced statistical analysis procedures including estimation of uncertainties
7. To evaluate the applicability of the methodology adopted by the European forest soil monitoring programme before setting up the monitoring for other land use types
8. To improve the existing QA/QC strategy for European forest soil condition survey

2. Materials and methods

2.1. Field survey

In the first pan European soil inventory, the soil type was described and characterised by means of soil augerings, and applying the Belgian soil classification system (Roskams, 1995). This soil classification system is a field classification system taking into account 1) the soil texture 2) the moisture status and 3) the profile development. In the ICP Forests Level I soil database, the plots received the best correlating FAO (1988) soil name (see Table 1). Based on this limited information, it is however not possible to classify the soil type accurately according to the International World Reference Base for Soil Resources (IUSS Working Group WRB, 2006).

This need for a detailed profile description and analytical characterisation is realised within the Flemish part of the BioSoil Level I project. In the summer of 2006 the site and profile description were made. The fieldwork was conducted with the help of the guidelines produced for BioSoil by the Forest Soil Co-ordinating Centre (Mikkelsen et al., 2006).

Table 1: The FAO (1988) soil classification of the 10 Flemish Level I plots in the 1993 survey

Code plot	Code profile	Location	FAO (1988)
12	201	Maldegem	Fimic Anthrosols
17	505	Schilde	Haplic Podzols
18	602	Beerse	Haplic Podzols
32	901	Hechtel	Carbic Podzols
39	207	Serskamp	Stagnic Alisols
44	406	Deurne	Haplic Arenosols
46	703	Opglabbeek	Haplic Podzols
55	404	Binkom-Lubbeek	Stagnic Alisols
57	801	Wimmertingen	Eutric Gleysols
58	803	Gellik	Carbic Podzols

Simultaneously with the soil inventory, the inventory of the biodiversity part of the BioSoil project was carried out by Sigrid Coenen in a circle with radius of 11.22 m(400 m^2) centred around the plot centre. The location of the profile pit was always located on a distance more than 20 m from the plot centre and avoided the immediate surrounding of the crown assessment trees. A separate inventory of the ground vegetation was made in the immediate vicinity of the profile pit. This explains why the vegetation data presented in this report might slightly differ from the BioSoil biodiversity report.

2.2. Laboratory analyses

The laboratory analyses on the samples taken in the profile pits were done in the course of 2007. The laboratory analytical methods follow partly the reference methods described in the ICP Forests Manual (2006) and partly the standard reference methods at the Analytical laboratory of the Research Institute for Nature and Forest, with some additional analyses for some profiles. An overview of the analytical methods is presented in Table 2 and Table 3. Note that some of the methods of derived soil variables might differ from the methods that will be applied on the data in the central BioSoil database.

Table 2: Overview of the analytical methods conducted on the samples taken from the horizons of the profile pits

Soil variable	**Method**	**Remarks**
Particle size distribution	Pipette method, SA03, ICP Forests Manual (2006) and ISO 11277	Following fraction limits are handled: 2, 10, 20, 50, 63, 100, 125, 250, 500, 1000 and 2000 µm. 50 µm is included to compare with national data. 125 µm included for classification purposes (Cambic horizon).
Coarse fragments	SA05, ICP Forests Manual (2006)	Laboratory measurement: mass % of total sample
$CaCO_3$	Acid – Base titration method	
Total N (Kjeldahl), Modified	SA09B, ICP Forests Manual (2006)	
Total N (Kjeldahl), Standard	Kjeldahl method	
Org. Carbon, TOC	SA08, ICP Forests Manual (2006)	
Org. Carbon, W&B	Walkley and Black Organic Carbon	unmodified method (no external heat applied)
OM LOI	Organic matter by Loss on Ignition	Combustion temperature: 550°C for 3 hours
Basic cations by NH_4OAc	NH_4OAc method	Only Ca, Mg, Na and K are measured. Detection limits are rather high. Required for proper classification of the soils according to WRB-2006 (IUSS Working Group WRB, 2006).
CEC(NH_4OAc)	Titration	

Table 3 (continued): Overview of the analytical methods conducted on the samples taken from the horizons of the profile pits

Dithionite extractable Al and Fe	Van Ranst et al., 1999	Expresses the content of free iron and aluminium (oxides) in the soil
Oxalate extractable Al and Fe	SA13, ICP Forests Manual (2006), ISRIC (2002)	
Exchangeable elements, Free H^+ and exchangeable acidity	ISO 11260 (1994) and ISO 14254 (1994)	Triple $BaCl_2$ extraction; Free H^+ and exchangeable acidity by titration
CEC($MgSO_4$)	ISO 11260 (1994) "Compulsive method"	
pH, 1:1, water	Potentiometric	Water soil relation 1:1; mass based
pH, 1:5, water	Potentiometric	Water soil relation 1:5; mass based
pH, 1:5, $CaCl_2$	Potentiometric	$CaCl_2$ solution to soil relation 1:5; mass based
Aqua regia extractable elements	SA11, ICP Forests Manual IIIa (2006)	Microwave digestion Extraction with $HCl:HNO_3$ of 1:3
Electric Conductivity (EC)	Potentiometric	Measured concomitantly with pH
Actual water content		The sample is dried at 30-35°C sufficiently long that no more humidity is lost. The weight loss expresses the actual water content (assuming no loss of humidity between sampling time and measuring the weight before drying).
BD_S soil (Bulk Density)	SA04, ICP Forests Manual IIIa (2006)	
BD_{FE} fine-earth	SA04, ICP Forests Manual IIIa (2006)	
pF values		On BD rings pF 0 to 2.7 is determined. On separate samples the pF at 3.4 and 4.2 is measured.

Table 4: Overview of the methods of the derived soil variables on the samples taken from the horizons of the profile pits

Derived/calculated soil variables	**Description**
BS % (Base saturation)	Percent of the basis cations with respect to the measured CEC by NH_4OAc. Values below detection limit are included for half of their LOQ value.
CEC of the clay	The CEC clay is first corrected by CEC coming from the organic matter (where CEC = 200 cmol(+)/kg OM). The remaining CEC is related to the clay content. Unreliable data are not presented (expert judgement). Values below LOQ are included for half of their LOQ value.
CEC (sum)	CEC obtained by the sum of the basic cations and Al^{3+}, Fe^{3+}, Mn^{2+}, Free H^+ by the $BaCl_2$ compulsive method
BS by CEC($MgSO_4$) %	The base saturation expressed as the sum of the basic cations with respect to the CEC measured by the $MgSO_4$ method. Values below detection limit are counted with for half of their LOQ value only.
Acidity (sum)	Sum of Al^{3+}, Fe^{3+}, Mn^{2+} and Free H^+ determined on the triple $BaCl_2$ extraction
C/N	C/N ratio's discussed in this report are based on either: [(%LOI/2)/%TotalN$_{modified}$] for the organic layers, or [%TOC/TotalN$_{modified}$] for the mineral horizons

2.3. Classification

The soils are all classified according to World Reference Base for Soil Resources version 2006 (IUSS Working Group WRB, 2006). At the onset of BioSoil the most recent version of the World Reference Base was the one dating from 1998 (FAO, ISRIC and ISSS, 1998). After the training courses had taken place and during the first field season a second version was launched. This version is the latest official version published and it was agreed among the BioSoil partners to apply throughout Europe the most recent version, i.e.2006. Later, a corrected version of WRB-2006 was realised (IUSS Working Group WRB, 2007), but this version is only available over internet since 2007 and is not registered as a separate publication. Although several corrections and important clarifications have been made in the version of 2007, this version WRB-2007 was not used in BioSoil.

The 10 Flemish Level I soils were classified on 3-4 levels. These are:

1. Simplified classification name, this includes the reference soil group and the two most important prefix qualifiers if any present. Although it was decided within Biosoil to make full classifications for all profiles, having more experience at the end of the project, this is not a realistic target mainly due to 1) lack of experience in soil taxonomy among the participating countries and 2) lack of sufficient field and laboratory data or even geological, hydrological, historical… data. If we could build a database of a few thousand soil profiles classified with a good accuracy to the level of reference soil group with 1-2 prefix qualifiers, the classification part of BioSoil would be a success.
2. Full classification name without specifiers, here all prefix and suffix qualifiers present in the soil are listed. This is the BioSoil level that normally should be reported as a minimum.
3. Full classification name with specifiers. Due to the arbitrary nature of most specifiers (when is a certain characteristic weak, normal or strong developed?) it was agreed to keep this level on a voluntary basis.
4. For a few soils facing classification problems an advanced classification name has been provided. When the classification key does not offer a solution due to the soil complexity a solution is suggested.

Although fieldwork and selection of samples for further laboratory analyses were carried out with uppermost care, during the process of classification problems of insufficient data or information were faced. Where possible these data were collected (e.g. asking for additional laboratory data), consulting the digital photographic material etc. If the required data could not be achieved and an expert judgement did not solve the problem a particular qualifier was ignored and the classification continued.

In the profile description the given depths take into account any variation of the horizon boundary. Indicated is the upper and lower limit of the begin and the end of the horizon limit, e.g. H3: 22/25-37/45 cm, means that the upper limit of H3 is found between 22 and 25 cm depth measured from the transition between horizon H2 and horizon H3. The lower limit of H3 is found between 37 and 45 cm.
In the tables of analytical data the indicated depths are simplified. Here the mean upper and lower horizon limits are presented. The mean has been obtained by estimating the mean from the profile sketches. A horizon boundary that as an example remains at 20 cm over 80% of the boundary and at the end dips to 30 cm will get the mean depth 22 cm (In the profile description it will be written 20/30 cm). These simplified depths have also been reported to the BioSoil database.

2.4. Structure of the report

In the following each of the soil profiles is described in a separate chapter. In each chapter 1) the site and profile description is given, followed by 2) the analytical lab data, 3) the information derived from the Belgian soil map, 4) the classification according to WRB 2006 and 5) the discussion focusing on how well the new classification name characterises the soil.

3. Profile 201, Maldegem, East Flanders

3.1. Site and profile description

Profile 201	**Maldegem (Level I forest plot)**
1.2 Date of description:	3/5/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of East Flanders, Maldegem Municipality. From Maldegem centre follow the Noordstraat (N410) in northern direction. After about 1.4 km turn to the west along the E34. After 1.1 km follow the Vakebuurtstraat in northern direction. After about 1 km follow the Paddepoelstraat in northern direction. After passing trough the forest, a field road on the left side is running parallel with the Paddepoel forest. Follow this field road. The experimental plot is situated in the small forest (150x150 m) at the right side of the field road (figure 1 and 2; photo 1).
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 12 *Code profile:* 201 *Latitude, longitude:* 51° 14' 06.27" N, 3° 25' 27.91" E (centre profile pit)
1.6 Elevation:	4 m a.s.l.
2.1 Atmospheric climate and weather condition:	Relatively dry in the weeks prior to the fieldwork. On the day of fieldwork it was sunny and 25-27 °C.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macrotopography:* The forest is located on a very gentle higher part in an almost flat terrain. About 350 m to the north of the plot, the Leopoldkanaal is running from east to west. Further to the north and northeast (5-10 km distance) at an altitude of 1-3 m, the landscape shows many evidences of a past creek drainage system. The area around the forest plot is characterised by a criss-cross pattern of drainage channels. *Mesotopography:* The forest floor is dominated by a ditch system with a distance between two ditches of 6 m (photo 2). The ditches are up to 2 m wide including very gentle sloping sides. The height difference between ridges and ditches is about 40-45 cm. The profile is constructed with the long axe parallel to the ditch direction. *Landscape position:* higher part *Slope form:* - *Slope gradient:* 2/3° or 1.5% *Slope length:* The general slope is about 2.5 km long and ends where the Leopoldkanaal breaks the topography. *Slope orientation:* dipping towards NW
2.4 Land-use:	Plantation forestry with selective felling. Natural regeneration. Oaks and poplars are planted. Oaks are planted in the zone of gentle ditch slopes. *Wildlife:* not protected *Grazing:* none
2.5 Human influence:	Vegetation slightly disturbed; raised beds, ditches with mutual distance of 6 m, ditches are running west-east; the entire area is artificially drained with deep ditches and pump stations
2.6 Vegetation:	Deciduous forest; deciduous shrub; short grassland in patches

Tree layer		Shrub layer		Herb layer	
Sycamore Maple	*Acer pseudoplatanus*	Sycamore Maple	*Acer pseudoplatanus*	Common Bracken	*Pteridium aquilinum*
Mountain Ash	*Sorbus aucuparia*	Common Hazel	*Corylus avellana*	Brambles	*Rubus sp.*
Poplar	*Populus sp*	Sweet Chestnut	*Castanea sativa*	Sycamore Maple	*Acer pseudoplatanus*
Sweet Chestnut	*Castanea sativa*	Elderberry	*Sambucus nigra*	Creeping Soft Grass	*Holcus mollis*
Pedunculate Oak	*Quercus robur*			Common Ivy	*Hedera helix*
				Mountain Ash	*Sorbus aucuparia*
				Redcurrant	*Ribes rubrum*
				Solomon's Seal	*Polygonatum*

2.7 Parent material:	Coversand (7220)
2.8 Drainage class:	Somewhat poorly drained *Availability of water:* excessive
2.9 Internal drainage:	Saturated for short periods in most years (up to 30 days)
2.10 External drainage:	Slow run-off
2.12 Groundwater:	*Highest groundwater table:* 50-100 cm *Lowest groundwater table:* 100-150 cm *Type of water table:* Permanent water table. Some perching on top of H7.
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	None
2.17 Surface cracks:	None
Humus classification:	The humus typology was studied on the following ridge from the profile, which is at 6 m distance. Here the OL was found to be 1-2 cm thick, the OF 0.5-1 cm and the OH less than 1 cm. The OH is zoogenic, although no earthworms were observed. The border to the underlying very humus rich A horizon is relatively sharp, although very irregular (photo 3). Faunal activity was observed in the Ajz horizon but is unevenly distributed. The faunal activity seems especially concentrated around the cracks, and where the organic matter content is high. While digging the ditches the soil was dumped in top of the original soil between the ditches. That explains why the A horizons are so thick. The new material on top has a discontinuous pore system, which allows water to drain but appears rather root restricting. This also explains why the concentration of roots and fauna is much higher in the underlying original Ahbi horizon (H5) than in the overlying new A horizon. Horizon sequence: OL, OFz, OHz continuous, Ajz. *Classification name:* Moder → **Eumoder**

No.		**Horizon description** (see also photo 4)
H1	OL	-12 till -7 cm; abrupt smooth boundary
H2	OFz	-7 till -6 cm; black 5YR 2.5/1 (M); mostly composed of fragmented and decomposed oak leaves; very high porosity
H3	OHz	-6 till -5/10 cm; black to dark reddish brown 5YR 2.5/1.5 (M); BD is estimated at <0.5 g/cm3; common very fine, few fine and none medium to coarse roots; some earthworms; the horizon thickness is rather irregular, in depression positions of the mineral soil organic matter has accumulated more extensively, clear wavy boundary
H4	Ah/Ajz	-5/10-23 cm; very dark brown to very dark greyish brown 10YR 2.5/2 (M), dark greyish brown 10YR 4/2 (D); humus mixed with uncoated sand grains (salt and pepper); loamy sand; coarse weak angular blocky; very friable, non plastic, non sticky; medium porosity; few very fine to medium and very few coarse roots; clear smooth boundary
H5	Ahbi	23-43 cm; black to very dark greyish brown 10YR 2.5/1.5 (M), dark greyish brown 10YR 4/2 (D); loamy sand; weak, medium to coarse granular and weak to medium, subangular blocky; very friable, non plastic, non sticky; medium porosity; common very fine to coarse roots, mostly horizontal due to an underlying root restriction layer; clear smooth boundary

H6	Bw	43-55 cm; brown 10YR 5/3 (M), pale brown 10YR 6/3 (D); positive reaction to α,α-dipyridyl throughout; sand; very friable, non sticky, non plastic; low porosity; few very fine and fine, very few medium and coarse roots; one burrow (mole?), 7 cm diameter, filled with greyish slightly more humeferous material than the horizon matrix, other burrows extend from H4 through H5 into H6; clear smooth boundary
H7	Cr	55-101 cm; light olive brown to light yellowish brown 2.5Y 5.5/3 (M), pale yellow 2.5Y 7/3 (D); few (2-3%), medium, distinct, diffuse, rusty orange mottles, throughout the horizon, strong brown 7.5YR 4/6 (strongest hue; W), dark yellowish brown 10YR 4/6 (normal hue; W); positive reaction to α,α-dipyridyl throughout; no traces of Mn, Fe concentrated in mottles; oximorphic properties, water table perching on top of H7; sand; massive; very friable, slightly sticky, non plastic; low porosity; none very fine to fine and few medium to coarse roots; abrupt smooth boundary
H8	2Cr	101-… cm; dark greyish brown 10YR 4/2 (M), greyish brown 10YR 5/2 (D); reduction along pores and peds, oxidised inside peds; positive reaction to α,α-dipyridyl throughout; clay; angular blocky; humus lining macro biopores due to generations of humus accumulation; slightly plastic; common medium to coarse roots, mostly horizontal; rooting depth more than 140 cm

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Photo 1: View on the small forest hosting the level I plot Maldegem (201). The forest is part of the Paddepoelebos. The tree row on the right side of the photo is marking the brinks of the Leopold channel (Photo JM).

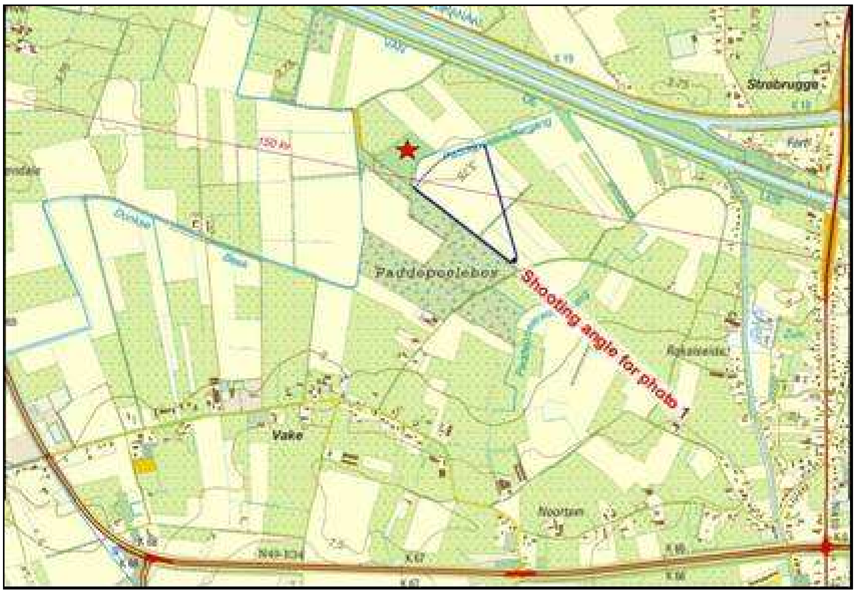

Figure 1: Topographical map of the area surrounding profile 201. The location of the profile is indicated by a red star.


Figure 2: Orthophotographical map with the location of the profile indicated by a red star

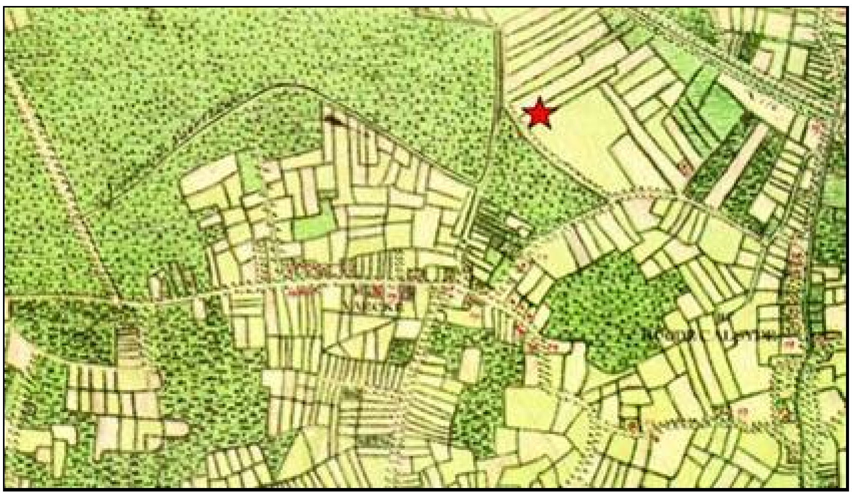
Figure 3: Ferraris (1777) map with the location of the profile indicated by a red star

Photo 2: The level I forest plot no. 201. The topography, the soils and the ground vegetation are dominated by the ditches (Photo JM).

Photo 3: Close up of the humus type (Photo JM).

Despite the zoogenic influence, a thin continuous OH horizon was observed. The humus type was classified as an Eumoder. The high input of organic material combined with the very wet nature of the soil may explain the rather slow decomposition of the litter.

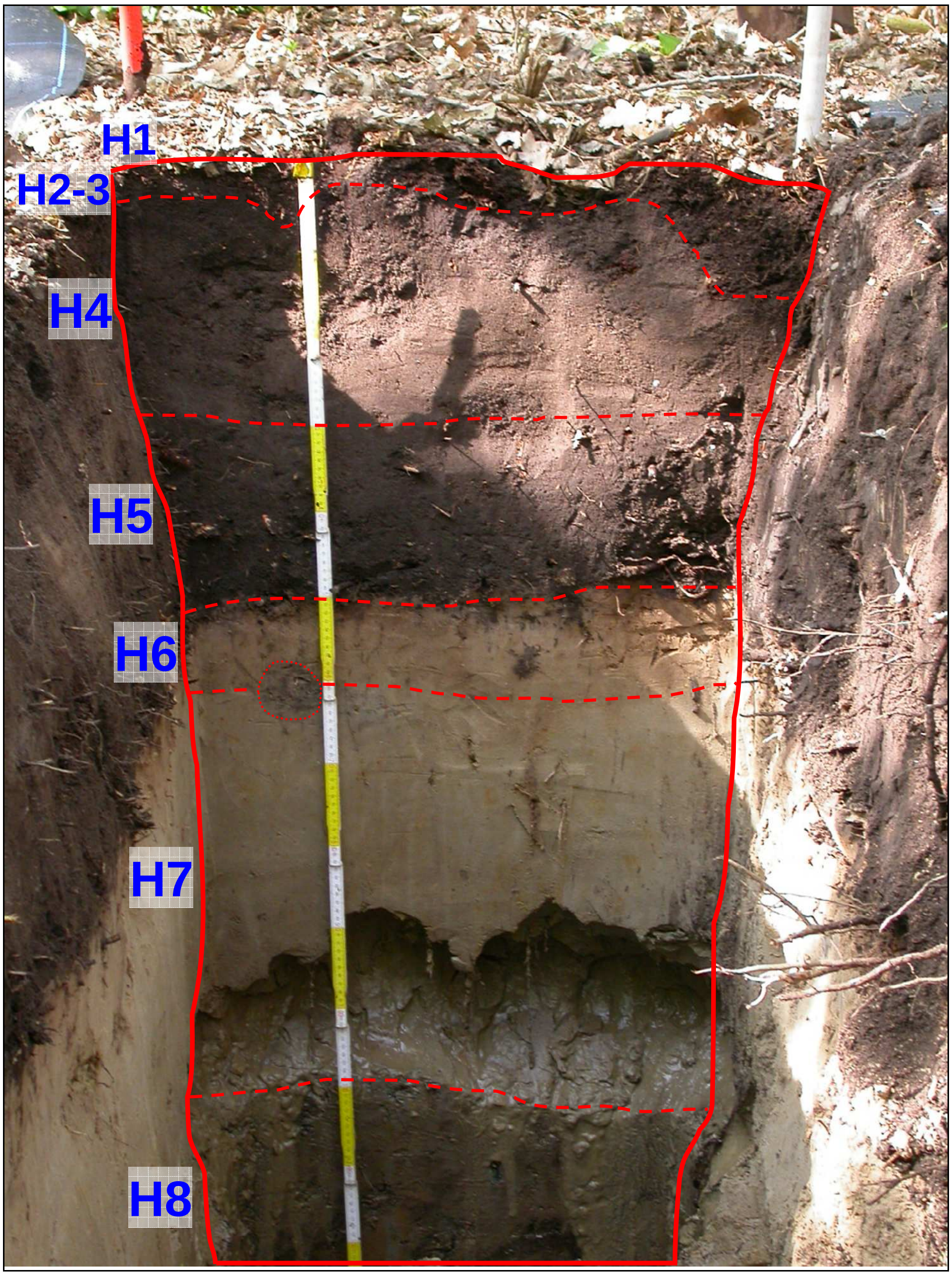

Photo 4: Soil profile 201 with the horizons indicated (Photo JMH).

3.2. Analytical data

In this soil the C/N ratio is high with values of 20 in the litter layers, and drops to 15-17 in the upper minerals horizons (Table 4). Deeper in the soil the ratio drops below 12. Despite the high C/N ratio earthworms were observed in the OH horizon. Two peaks of organic carbon are found, one in the A horizons (3.1-3.6%) and one in the deepest horizon (1.5%).

Table 5: Analytical data for profile 201, Maldegem, East Flanders, Belgium. Profile studied 3/5/2006. Profile analysed: 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Total N (Kjeldahl) Standard %	Org. Carbon TOC %	Org. Carbon W&B %	OM LOI %	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm %-wght
1	OL	12-7									
2	OF	7-6	1.993				81		4.0	3.6	
3	OH	6-0	1.732				70		3.2	2.7	
4	Ah	0-23	0.189	0.200	3.13	3.1		3.4	3.8	3.2	0.2
5	Ahbi	23-43	0.235	0.241	3.62	3.6		3.5	4.0	3.5	0.1
6	Bw	43-55	0.035	0.054	0.28	0.3		4.0	4.4	4.0	0.0
7	Cr	55-101	0.024	0.038	0.06	<0.1		4.2	4.8	4.1	0.0
8	2Cr	101-	0.166	0.168	1.48	2.3		7.1	8.0	6.8	

Horizon nr.	Particle size distribution (fractions in µm) 0-2	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
	--%--										
1											
2											
3											
4	3.1	1.7	1.4	7.5	1.3	17.2	15.9	46.9	4.4	0.3	0.0
5	3.8	1.5	1.6	10.2	2.2	19.5	17.4	40.0	3.2	0.1	0.1
6	0.7	0.8	1.0	3.4	1.6	20.0	19.9	48.9	3.4	0.1	0.1
7	1.8	0.8	0.1	4.9	2.7	22.8	19.4	43.0	3.9	0.2	0.3
8	45.4	6.6	7.1	23.1	0.5	3.4	2.7	10.0	1.0	0.0	0.0

Horizon nr.	Mg++	Na+	K+	Ca++	CEC	BS	CEC/clay	Al	Fe	Al	Fe
	by NH_4OAc cmol(+)/kg soil					%		Dithi. Citrate %		Oxalate %	
1											
2	4.71	0.41	2.16	24.14	71.8	44				0.047	0.107
3	1.42	0.22	1.03	8.04	64.5	17				0.035	0.075
4	0.11	<0.22	0.06	0.35	10.5	5		0.112	0.262	0.075	0.168
5	0.12	<0.22	0.05	0.39	12.2	5		0.182	0.344	0.165	0.219
6	0.05	<0.22	<0.13	0.13	1.7	11		0.090	0.056	0.046	0.016
7	0.09	<0.22	0.01	0.33	1.7	26		0.151	0.074	0.034	0.016
8	1.55	0.50	<0.13	15.54	10.7	>100	12			0.082	0.136

Horizon nr.	Horizon symbols	Depth cm	Mg++	Na+	K+	Ca++	Al+++	Fe+++	Mn++	Free H+	Lab nr.
			by $MgSO_4$ (compulsive method) cmol(+)/kg soil								
1	OL	12-7									JM67a
2	OF	7-6	4.13	0.28	2.15	27.13	<0.19	<0.03	0.205	3.82	JM67b
3	OH	6-0	0.88	<0.09	1.05	10.26	1.13	0.24	0.059	7.94	JM67c
4	Ah	0-23	<0.12	<0.02	0.13	0.21	2.80	0.13	0.004	0.86	JM68
5	Ahbi	23-43	<0.12	<0.02	0.12	0.26	4.09	0.13	0.004	0.47	JM69
6	Bw	43-55	<0.12	<0.02	0.04	0.09	1.09	<0.01	<0.002	0.21	JM70
7	Cr	55-101	<0.12	0.02	0.08	0.32	0.80	<0.01	<0.002	0.10	JM71
8	2Cr	101-	1.22	0.76	0.04	17.70	<0.04	<0.01	<0.002	0.10	JM72

Horizon nr.	CEC sum cmol(+)/kg	CEC measured cmol(+)/kg	BS by CEC-m %	Acidity sum cmol(+)/kg	Acidity titrated cmol(+)/kg	K	Ca	Mg	Na	P	S
						Aqua Regia mg/kg					
1						2931	15514	1690	228	1638	2495
2	37.7	33.6	>100	4.0	4.9	1217	6899	799	153	1122	2938
3	21.6	21.2	<58	9.4	10.7	783	2200	389	104	722	2741
4	4.1	4.8	<8	3.8	4.3	791	739	669	63	400	362
5	5.1	5.6	<8	4.7	5.8	713	831	748	70	210	491
6	1.4	<4	<10	1.3	1.2	579	725	482	58	29	66
7	1.3	<3	<34	0.9	6.3	748	1081	759	44	111	34
8	19.8	9.9	>100	0.1	<3.8	3099	10437	7806	471	436	421

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC dS/m 1:5	$CaCO_3$ %
	Aqua Regia mg/kg										
1	638	0.85	13.7	889	166	2	34.2	3.0	140		
2	1558	0.60	19.5	2228	76	4	167.1	5.1	99	0.57	
3	2262	0.30	19.6	3030	30	6	121.6	5.0	49	0.23	
4	6720	0.14	3.2	5458	37	13	28.4	3.1	11	0.06	
5	8727	0.38	3.8	6655	51	17	16.7	4.7	13	0.07	
6	4678	0.04	0.8	2007	36	10	2.0	2.0	7	0.03	
7	4785	0.02	0.6	2981	44	13	2.3	3.7	12	0.03	
8	18826	0.13	10.7	12270	130	36	7.3	24.2	38	0.17	4.3

The pH shows a steep increase with depth. In the Ah horizon the soil is very acid [pH(H_2O)= 3.4] and at one meter depth (H8) the pH(H_2O) 1:1 is 7.1. A content of 4.3% calcium carbonate explains the high pH at this level.

A minor content of coarse fragments, not exceeding 0.2% is mostly composed of larger fragments of organic matter such as roots. The particle size distribution is relatively homogeneous for the upper 4 mineral soil horizons. Between H7 and H8 an abrupt textural change is evident, as the clay content increases from 1.8 to 45%.

The content of nutrients in the soil varies with depth. In the organic layers the content of basic cations is high. But also in the calcareous subsoil (H8) a high basic cation content has been measured. In H8 this concerns merely Ca^{2+} and Mg^{2+}, while K^{+} is nearly absent. The saturation on the cation exchange complex by aluminium is only 5% in the OH horizon but increases to values between 60-80% in H4-7. In H8 the aluminium saturation is only 0.1%. This is an example of a soil where the nutrients not only are present in the organic top layers but also in the clayey substratum. As the substratum starts at 100 cm it is easily within reach of the tree roots. The aqua regia extractable elements show normal levels, although the content of sulphur in the litter layers is relatively high compared with the other analysed soils.

The bulk density is low (around 1.0-1.1 g/cm^3) in the A horizons and increases to 1.6 g/cm^3 in the sandy subsoil, a level that is typical for sandy horizons with little organic matter (Table 5). A bulk density of 1.45 g/cm^3 in the clayey substratum is also within the range typical for more clayey horizons.

Table 6: Bulk density (BD) and water retention (pF) for profile 201, Maldegem, East Flanders, Belgium

Horizon nr.	Horizon symbols	Depth	Actual water cont.	BD_S soil	BD_{FE} fine earth			Lab nr.
		cm	%	g/cm3	g/cm3			
1	OL	12-7	82					JM67a
2	OF	7-6	173					JM67b
3	OH	6-0	184					JM67c
4	Ah	0-23	27	1.08	1.08			JM68
5	Ahbi	23-43	32	0.98	0.98			JM69
6	Bw	43-55	17	1.59	1.58			JM70
7	Cr	55-101	17	1.64	1.64			JM71
8	2Cr	101-	30	1.45	1.45			JM72
Horizon nr.	**pF 0.0**	**pF 1.0**	**pF 1.5**	**pF 2.0**	**pF 2.3**	**pF 2.7**	**pF 3.4**	**pF 4.2**
	---------- Vol. % water ----------							
1								
2								
3								
4	52.1	49.8	45.9	28.8	24.9	16.3	16.6	2.5
5	47.8	46.2	39.9	26.2	23.7	15.6	15.6	3.8
6	50.4	47.8	43.2	25.1	19.4	5.5	3.7	1.1
7	55.3	50.9	47.9	28.8	22.9	4.1	5.2	2.0
8	57.1	54.2	51.4	46.8	45.2	36.1	31.6	18.9

The water holding capacity is good, with 25-46 % at field capacity and 1-19% at wilting point. Figure 4 presents the available data for horizon 4-8. Note how several horizons show an increase in water content from pF 2.7 to 3.4. The results for pF 0.0-2.7 are based on bulk density rings containing 100 cm^3 of undisturbed soil material. For each sampling depth 5 replicates were taken. For pF 3.4 and 4.2, a different subsample from the same horizon was applied in the laboratory, which occasionally gives an unusual bend to the pF curve. The results are not wrong, but they illustrate the variability and complexity of soils and demonstrate the importance of taking replicates.

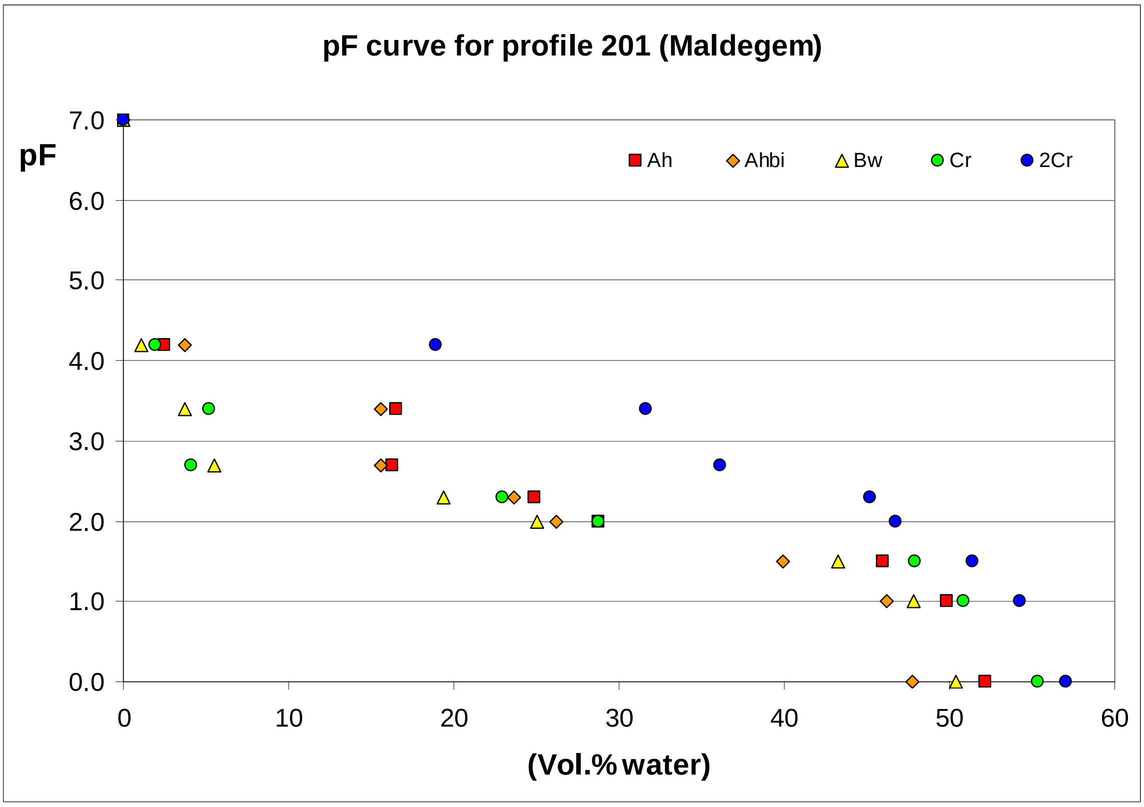

Figure 4: pF curve for profile 201

Photo 4 shows how the water is stagnating in top of H8. The explanation is clear as H7 contains 1.8% clay and H8 45.4%. This heavy clayey substratum not only explains why water is stagnating in this profile, but probably can explain the general rather wet landscape morphology characterising the area of the Paddepoelebos. The very thick humus rich topsoil is composed of an original A horizon (H5) with material added on top originating from digging and possible from cleaning of the ditches (H4). H4 has a more compact nature and probably has a discontinuous pore system, which may explain why the frequency of roots is higher in H5. The content of roots in H8 is one of the highest, which is contrasting the low content found in H6-7. Firstly, it is difficult for the roots to find a way through H6-7 for this reason many roots grow horizontally at the bottom of H5. Secondly, the nutrients and the water obviously are found in H8. The roots found in this depth are medium to coarse sized tree roots. For agriculture this is a poor sandy soil, for forestry this seems a good soil with water and nutrients within reach ones the trees have reached a certain age.

3.3. Information deduced from the Belgian soil map

Soil profile 201 Maldegem (Paddepoelebos) is located on soil map Maldegem 24W which is bordering to the north to The Netherlands. The soils on the map are mostly composed of sands, with in the southern edge of the map units of more clayey nature.

The soil profile is enclosed in a small map unit Zch with strong human impact. In the immediate surroundings we find Sdh, Zdh and Sep soil units (Figure 5).
A concise meaning of the symbols are as follows:

- Zch: Moderately dry sandy soil with degraded humus and/or iron B-horizon
- Zdh: Moderately wet sandy soil with degraded humus and/or iron B-horizon
- Sdh: Moderately wet loamy sand soil with degraded humus and/or iron B-horizon
- Sep: Wet soils on loamy sand

The map unit Zch where the soil profile is located is described as a Postpodzol. That is described by Ameryckx and Tavernier (1962) as a soil with the horizon sequence Ap, Bhs, Bs, C. The E horizon and sometimes part of the Bh horizon have been included through ploughing into the Ap horizon. The Ap is 30-50 cm thick and contains a mean of 2.4% humus. From a depth of 60-90 cm rusty mottles appears. The map unit has furthermore received the legend 'strong anthropogenic influence'.

Only along the dirt road leading towards the level I forest plot and the small forest hosting the plot, the combination of Zch with strong anthropogenic influenced has been mapped.

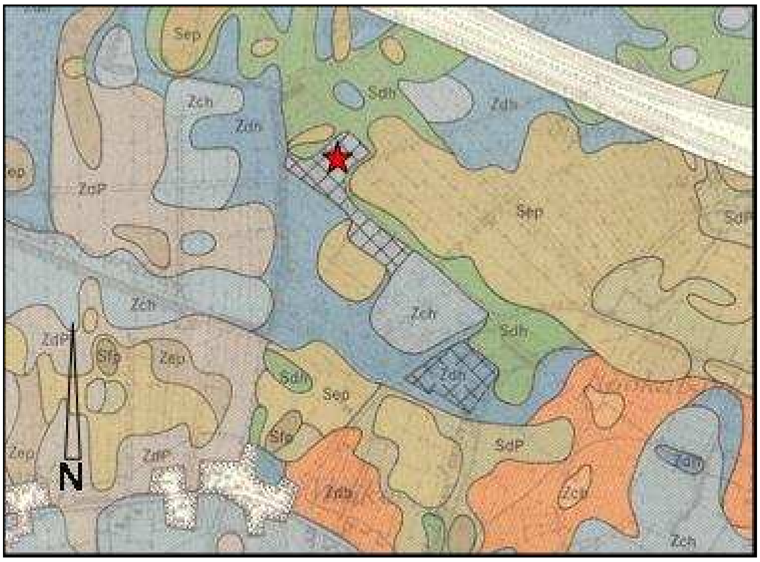

Figure 5: Detail of the soil map 'Maldegem 24W (Ameryckx and Tavernier, 1961). The forest site is located on map unit Zch with a strong anthropogenic influence.

The map unit (Figure 5) hosting the experimental forest site, appears rather squared. Raising of the land (H2-4) in an environment generally rather wet seems the most reasonable explanation. This fits with the soil record, where the A horizon is considered abnormally thick in comparison with the soil quality (rather sandy and acid). Originally H5 was the surface horizon, which implies that at least 23 cm of humus rich mineral soil material has been added on top. Possibly a part of H5 is composed of dumped material as well. The squared form of the area with addition of soil material is most probably linked with a different landownership than for the surrounding unraised fields.

3.4. Classification according to World Reference Base (2006)

It is not completely clear whether this profile is under influence of a permanent and fluctuating groundwater table or whether it is dominated by stagnic water. Considering that H8 is starting at 101 cm depth composed of 45% clay and the horizons above only containing 0.7-3.8%, it is most likely that after rainfall the water reaches rather fast the clayey soil horizon where it will stand until it drains vertically or laterally. The entire area is artificially drained. In nearby drainage channels the water level was clearly lower than the total depth of this soil profile. In the following, the soil is classified having a stagnic rather than a groundwater problem.

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H7	The horizon is morphologically described as a C horizon, but due to reducing conditions the colour requirement is fulfilled.
Folic	H1-3	
Plaggic	-	No artefacts nor spade marks observed
Umbric	H4-5	
Abrupt textural change	Between H7-H8	

Lithological discontinuity	Between H7-H8	
Reducing conditions	H6-8	
Stagnic colour pattern	H7-8	

Simplified classification name
Stagnic Folic Umbrisol

Full classification name without specifiers
Stagnic Folic Umbrisol (Albic, Humic, Alumic, Hyperdystric, Arenic) • Brunic, H6 qualifies according to all criteria for Cambic (except for texture) but it is too thin • Alumic present in H6-7 (based on CEC by the $BaCl_2$ method) • Hyperdystric; BS is as low as 5 % in some horizons • Humic, weighted average of the OC in the mineral soil from 0-50 cm depth is 2.93%, sufficient for Humic (>1%) but insufficient for Hyperhumic (>5%)

BioSoil classification name (WRB 2006), with specifiers
Endostagnic Folic Umbrisol (Endoalbic, Humic, Alumic, Hyperdystric, Arenic)

3.5. Discussion

Profile 201 is situated within a forest of a particular small size, in fact when standing in the centre the edge of the forest can be spotted on 3 sides. The soil is characterised by a series of important factors, these are:

- A rather clayey subsoil, which results in stagnating water after heavy rainfall or periods of cumulative high precipitation. This slow permeable layer not only prevents the water from draining but also stores considerable amounts of nutrients. It is therefore evident that the high content of organic matter found in this substratum is directly related to many generations of roots, which have decayed. Common living roots were observed during the fieldwork at this depth.
- Originally the soil is composed of 60 cm sandy soil resting on top of the clayey substratum. Apparently this was too wet for agriculture and the land was raised with 20-25 cm of organic rich sandy material (see also Figure 3).
- It is not clear what happened first: either the raising of the land or the general lowering of the water as the very deep drainage channels and the presence of water pump installations may indicate. What is triggering is that the new A horizon hosts much less biological activity such as roots and has clearly a less developed pedality than the original A horizon. These are arguments to assume that the raising of the land occurred shortly before planting of the forest.
    - A hypothesis would be that the original A horizon was formed during a period of agricultural activity, either cropland but probably rather meadow. During this period the A horizon received sufficient manure and/or fertilizer to maintain a good environment for an active earthworm population. Shortly after the land was raised the forest was planted and the soil remained unfertilized. Due to the sandy nature of the soil the topsoil was fast depleted from nutrients and became increasingly more acid. This resulted in a rapid decline of the mesofauna and this before it could sufficiently mix the new with the original A horizon.

The soil has a root limiting layer in H6 with only few roots being able to pass through. This has resulted in a very high concentration of roots in the lower part of H5. Some roots manage to find a way through and end up in the clayey layer where they spread out.

The WRB classification name "**Endostagnic Folic Umbrisol (Endoalbic, Humic, Alumic, Hyperdystric, Arenic)"** resembles accurately the characteristics of profile 201. The very thick humus rich A horizon is expressed in the Umbrisol. The thick litter layer on top and the stagnic properties above the clayey horizon are indeed other important aspects of the soil.

On the other hand, the FAO (1988) soil classification name 'Fimic Anthrosol' given to the site in 1993, merely focused on the man-made character of this soil. This aspect is lost in the WRB-2006 name since there were not enough evidences to fit the requirements of a plaggic diagnostic horizon.

4. Profile 207, Serskamp, East Flanders

4.1. Site and profile description

Profile 207	**Serskamp (Level 1 forest plot)**
1.2 Date of description:	4/5/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province East Flanders, Wichelen Municipality. On highway E40 take exit Wetteren (17) direction Wetteren and follow road N417. While approaching Wetteren continue straight along Serskampsteenweg. After about a kilometre the street changes name into Wetterensteenweg. Where the road splits, follow the Galgenberg road in south-eastern direction. After about 300 m take in southern direction the road Doornstraat. This road turns after about 200 m into a field road that after 450 m into a dirt road. At the end of this road, which passes a tree nursery located on the left side, the forest plot is located a bit downhill (photo 5). Within the forest plot the profile is located between two ditches, with its long side parallel with these ditches (photo 6).
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 39 *Code profile:* 207 *Latitude, longitude:* 50° 58' 46.53" N, 3° 55' 22.00" E (centre profile pit)
1.6 Elevation:	±17 m a.s.l.
2.1 Atmospheric climate and weather condition:	Sunny with clear sky (25-27 °C). Little rain in the weeks prior to the fieldwork.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The forest plot is located in a very gently rolling landscape with altitudes between 15 and 30 m above sea level. Towards north at a distance of 3.5-4 km the Schelde river is running from west to east. To the north of this river the landscape is much more flat with altitudes not exceeding 10-15 m (figure 6 and 7). *Mesotopography:* The profile is located on a south facing slope *Landscape position:* Lower slope *Slope form:* CS (concave, straight) *Slope gradient:* 1 $^{2}/_{3}$°, or 3.7% *Slope length:* The total slope length is 500 m, where the profile is located at about 100 m from the tributary valley. The effective slope length is about 30 m, which is the length from the road dividing the upland tree nursery from the studied forest plot. *Slope orientation:* 190° south
2.4 Land-use:	Plantation forestry with no evidences of felling. *Wildlife:* probably not protected *Grazing:* no grazing
2.5 Human influence:	No direct influence on the ground vegetation. Before the forest was planted, ditches were constructed parallel with the slope direction, which obviously has had an impact on the ground vegetation. Ditches: they are found with a mutual distance of 6 m and a depth of 30-40 cm. They are dipping in southern direction (160°)
2.6 Vegetation:	Deciduous woodland, in the immediate vicinity of the profile and towards north, east and south the forest is dominated by oak

	(>90%). At about 9 m to the west a different forest is planted with poplar (>90%).

Tree layer		Shrub layer		Herb layer	
Mountain Ash	*Sorbus aucuparia*			Common Bracken	*Pteridium aquilinum*
Poplar	*Populus sp*			Brambles	*Rubus sp.*
Pedunculate Oak	*Quercus robur*			Stinging nettle	*Urtica dioica*
				Cleavers	*Galium aparine*

2.7 Parent material:	Loamy loess (7110)
2.8 Drainage class:	Moderately well drained *Availability of water:* Sufficient
2.9 Internal drainage:	The soil near the surface is saturated for short periods in most years. The saturation will mostly occur in the winter and early spring.
2.10 External drainage:	Moderately rapid run-off The soil is never flooded
2.12 Groundwater:	Deep (110 cm depth). The presence of the completely reduced 2Cr horizon could indicate the upper limit of the permanent ground water zone.
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	None
2.17 Surface cracks:	None
Humus classification:	Following sequence of humus classification horizons was observed: OLn-OFz-OHz-Aze. A good faunal activity was observed in the OF horizon, and small earthworms and centipeds in the OH horizon (photo 7). *Classification name:* Moder → Dysmoder

No.		**Horizon description** (see also photo 8)
H1	OLn	-7 till -5 cm
H2	OFz	-5 till - 4 cm
H3	OHz	-4 - 0 cm; very dark brown 10YR 2/2 (M); strongly developed, medium sized granular; loose; very high porosity; common very few to medium roots; abrupt smooth boundary
H4	Ah/Aze	0-2 cm; very dark greyish brown 10YR 3/2 (M), greyish brown 10YR 5/2 (D); moderately developed, medium sized granular; very friable; medium porosity; common very few to medium roots; abrupt smooth boundary
H5	Bhs	2-7 cm; very dark greyish brown to greyish brown 10YR 3.5/3 (M and W), pale brown 10YR 6/3 (D); positive reaction to α,α-dipyridyl; loam; weak, coarse angular blocky; friable; few very fine, common fine and very few medium roots; abrupt smooth boundary
H6	E	7-15 cm; brown 10YR 4.5/3 (M), pale brown to very pale brown 10YR 6/3.5 (D); positive reaction to α,α-dipyridyl; silt loam; porous massive; very friable; low porosity; root distribution as in H4; one soil fragment similar to H7 embedded in this horizon, possible the result of a single time ploughing; abrupt smooth boundary
H7	Apb	15-30 cm; brown 10YR 4/3 (M), pale brown 10YR 6/3 (D), dark greyish brown 10YR 4/2 (W); positive reaction to α,α-dipyridyl; silt loam; weak, coarse to very coarse angular blocky; very friable; low porosity; few very fine, common fine and few medium roots; textural heterogeneity and irregular distribution of organic matter probably result of a single time ploughing; clear smooth boundary
H8	Btg	30-43 cm; brown 10YR 4/3 (M), very pale brown to pale yellow 1.5Y 7/4 (D); common (5-10%), medium, distinct, clear rusty orange to red mottles; positive reaction to α,α-dipyridyl; silt loam; moderate, coarse angular blocky; very friable; high porosity; few very fine and common fine roots; clear smooth boundary
H9	Btdg	43-71 cm; horizon is composed of: 1) bleached tongues, light yellowish brown 2.5Y 6/4 (M and W), pale yellow 2.5Y 8/2 (D), and 2) mottles, many (25-30%),

		coarse rounded, prominent, clear, yellowish brown to light olive brown 1.5Y 5/6 (M); positive reaction to ɑ,ɑ-dipyridyl; root gley; silt loam; strong, coarse (8-10 cm diameter) prisms, breaking to moderate, coarse angular blocky; friable; low porosity; few fine roots; gradual smooth boundary, which is drawn on basis of mottle density
H10	2BCg	71-105 cm; olive grey 5Y 5/2 (M), light grey 5Y 7/2 (D); abundant (±80%), coarse, prominent, clear, yellowish brown 10YR 5/6 (M) mottles; bleached parts concentrated on ped faces, along macro pores and nearby roots; positive reaction to ɑ,ɑ-dipyridyl; clay; strongly developed, coarse (8-10 cm diameter) prisms that extends from horizon above and through this horizon; friable; low to medium (4-7%) porosity; few very fine roots; clear smooth boundary
H11	2Cr	105-… cm; olive to pale olive 5Y 5.5/3 (M), light grey 5Y 7/2 (D); few (3-5%), coarse, prominent, clear, yellowish brown 10YR 5/6 (W and MC) mottles; positive reaction to ɑ,ɑ-dipyridyl; clay loam; massive; very friable; low porosity; few roots present often with bluish reduced colours lining the root galleries

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Photo 5: View on the part of the forest hosting the level I forest plot 207. Notice the change in species composition between to the left oak and to the right poplar (Photo JM).

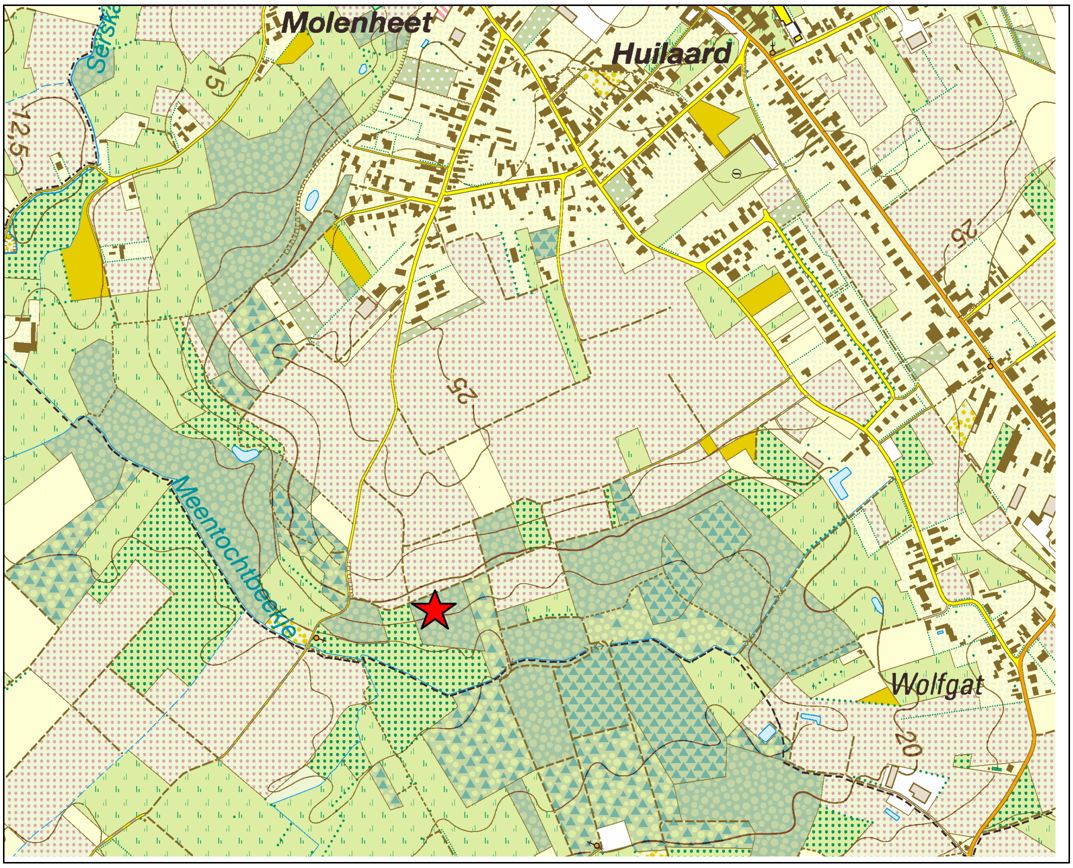

Figure 6: Topographical map of the area surrounding profile 207, Serskamp. The location of the profile is indicated with a red star.

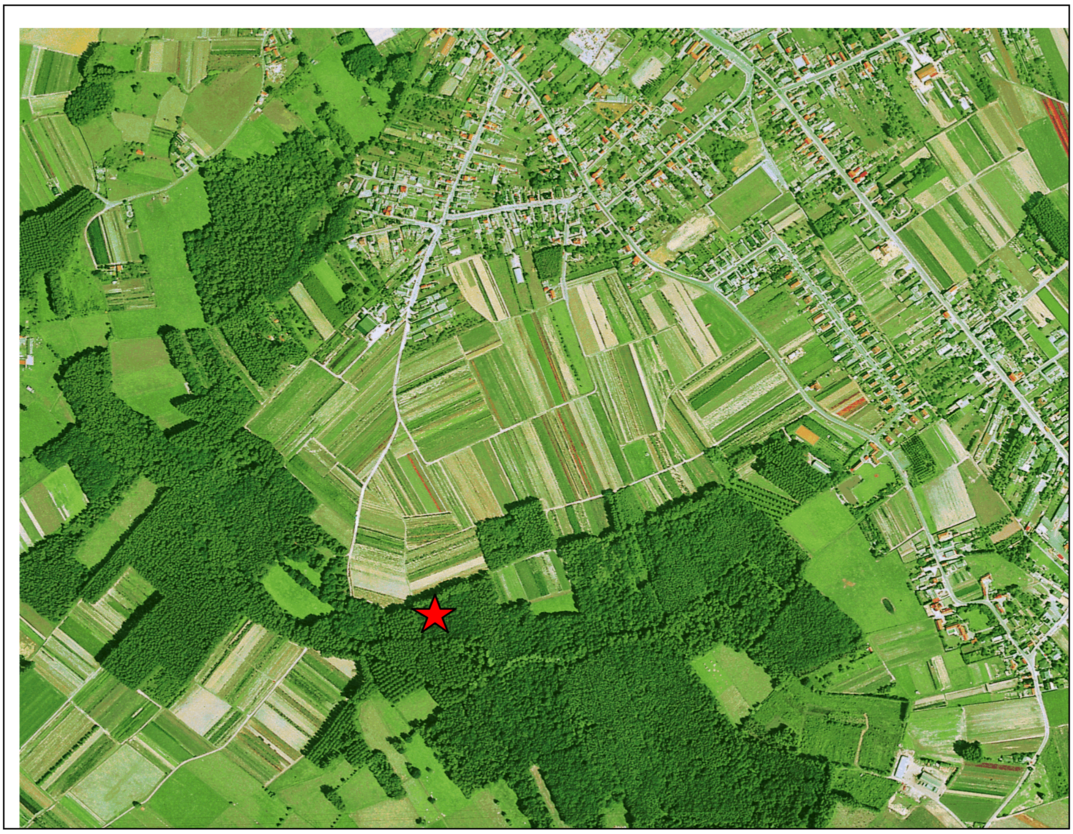
Figure 7: Orthophotographical view of the area surrounding profile 207, Serskamp. The location of the profile is indicated with a red star.

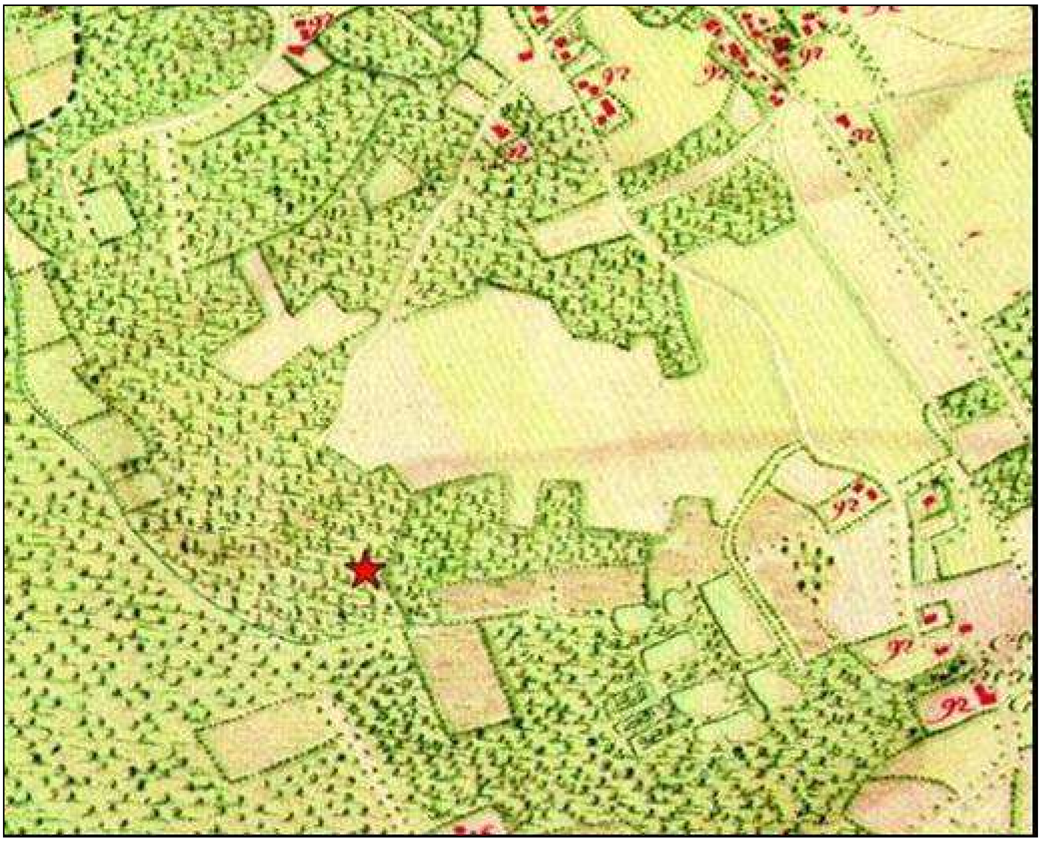

Figure 8: Cut out of Ferraris (1777) map 47- Wetteren. The location of the soil profile is indicated with a red star.

The area covered by forest has strongly decreased over the past 2 centuries as it is clearly visible in Figure 8. Most probably the area around the profile has always been covered by forest, the rather wet soil and so low suitability for agriculture is probably the main reason.

Photo 6 (left): View on the part of the forest where the profile was studied more or less in the centre of the photo (Photo JM).
Photo 7 (right): The humus type was described as Dysmoder, here nicely illustrated (Photo JM).

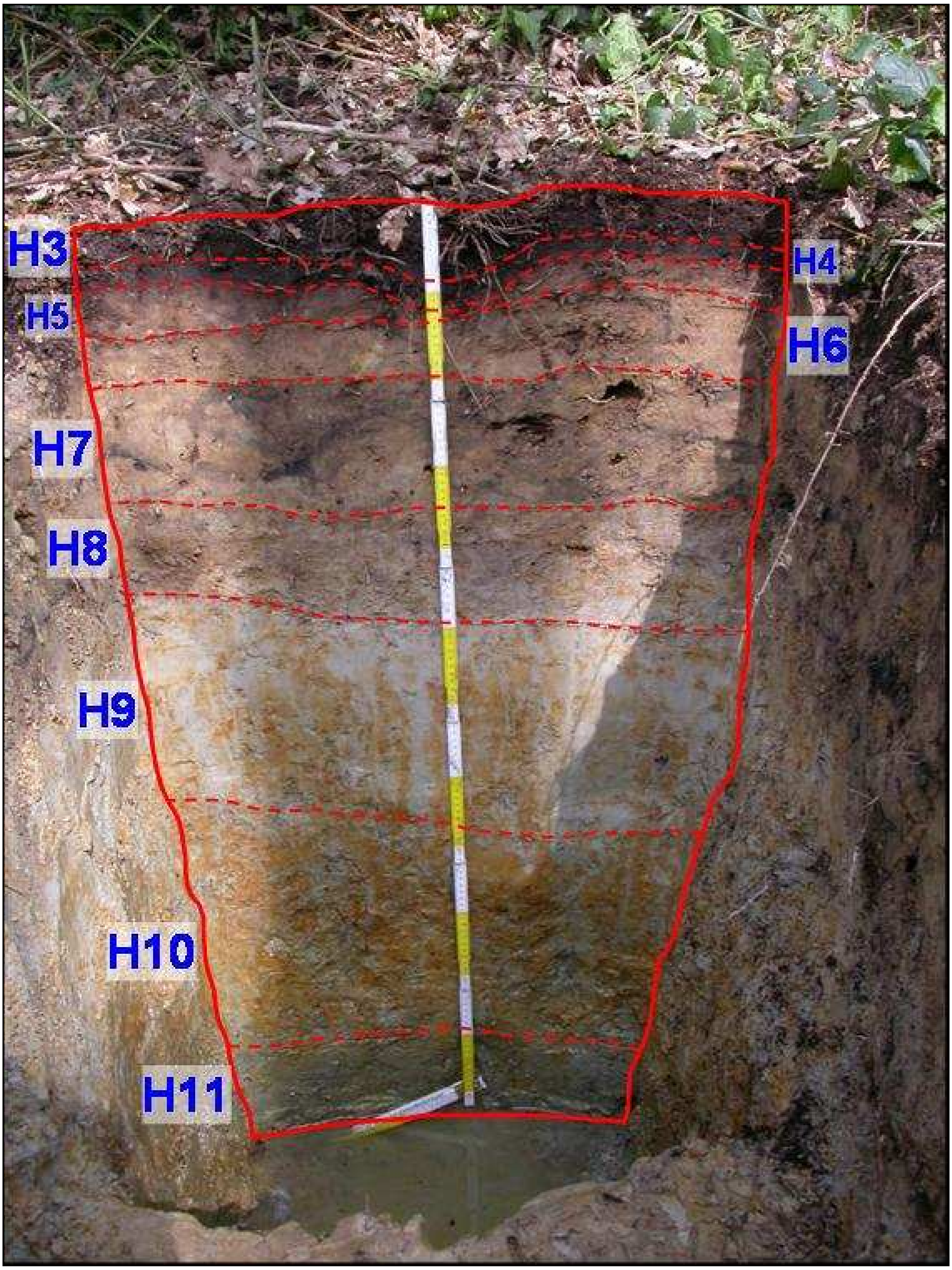

Photo 8: Soil profile 207 with the horizons indicated. The problems with stagnating water and the bleached albeluvic tonguing is clearly visible (Photo JM).

4.2. Analytical data

Table 6 shows the results of the laboratory analyses. The C/N ratios for profile 207 are in the range 14-19, except for the OF horizon where a ratio of 23 is present. Ratios below 12 are considered good, as the soil contains sufficient nitrogen to enhance the decomposition of the organic matter. If the ratio exceeds 20 the decomposition will be very slow. The content of organic carbon is 6.1% in the Ah horizon, but this horizon is only 2 cm thick. Below values of 1-1.6% prevail to a depth of 40-45 cm. Compared to other soils of this report, this soil does not have a particular high carbon content. The pH is acid in the OF horizon and declines then rapidly into the Ah horizon where the pH(H_2O) 1:5 is only 3.8. A more or less steady level is found further in depth until H10-11 where the soil has a neutral pH. This high pH is confirmed at least for H11 where a content of 0.9% calcium carbonate was measured.

Some very small fractions of coarse fragments were measured during the preparation of the samples for the laboratory. The coarse fraction left on the 2 mm sieve is composed of larger organic matter fragments and slightly cemented pseudo particles. The particle size distribution of H5-9 is relatively homogeneous, despite that in H8 the content of clay increases from 8.2% to 14.1%. This increase is most probably due to clay migration. H10-11 contains 38-40% clay, nearly no fine and medium silt and only half the coarse silt as found above. Also the content of fine sand (100-250 µm) is higher in H10-11. The presence of an abrupt textural change between H9 and H10 is evident from the presented data.

As expected, most basic cations are stored in the litter layer, especially in the OF layer. The base saturation in the OF is 90% and only 34% in the OH horizon. This difference can be because of a relatively high content of mineral material in the OH either through natural mixing or due to incorrect sampling. In the subsoil the content of basic cations is very low, except for the clayey substratum (H10-11) where base saturations of 100% were calculated.

For the subsoil horizons with a very low content of basic cations the aluminium saturation ranges from 65-80%. The CEC of the clay is moderate in the subsoil and low in the substratum. The very low values of the substratum (9-17 cmol(+)/kg clay) suggest that the clay minerals present have undergone long periods of weathering somewhere in the past but special analyses of the clay minerals are requested to take this hypothesis further.

The content of dithionite extractable iron is peaking in H8 and H10. For both horizons the content exceeds 1%. The relatively high content in H8 is not directly evident. The concentration in H10 is obviously due to oxido reduction with accumulation of iron in orange brown mottles.

Table 7: Analytical data for profile 207, Serskamp, East Flanders, Belgium. Profile studied 4/5/2006. Profile analysed: 09/2006 - 02/2007.

Horizon nr.	**Horizon symbols**	**Depth**	**Total N** (Kjeldahl) **Modified**	**Standard**	**Org. Carbon TOC**	**W&B**	**OM LOI**	**pH H_2O 1:1**	**pH H_2O 1:5**	**pH $CaCl_2$ 1:5**	**Coarse frag. >2mm**
		cm	%	%	%	%	%				%-wght
1	OL	7-5									
2	OF	5-4	1.918				88		5.6	5.1	
3	OH	4-0	1.107				37		3.9	3.3	
4	Ah	0-2	0.381	0.326	6.13	4.5			3.8	3.3	
5	Bhs	2-7	0.114	0.124	1.59	2.3			4.1	3.5	0.02
6	E	7-15	0.081	0.106	1.24	1.3			4.3	3.6	0.00
7	Apb	15-30	0.099	0.150	1.52	1.6			4.2	3.7	0.02
8	Btg	30-43	0.059	0.069	1.12	1.2			4.4	3.8	0.02
9	Btdg	43-71			0.10	0.2			4.8	4.1	0.00
10	2BCg	71-105			0.14	<0.1			7.0	6.0	0.00
11	2Cr	105-			0.14	<0.1			7.2	6.2	0.00

Horizon nr.	**0-2**	**2-10**	**10-20**	**20-50**	**50-63**	**63-100**	**100-125**	**125-250**	**250-500**	**500-1000**	**1000-2000**
	Particle size distribution (fractions in µm) ---%---										
1											
2											
3											
4											
5	8.7	4.4	6.6	35.6	2.3	12.1	6.6	19.5	3.7	0.3	0.0
6	9.2	5.0	6.5	41.0	2.6	11.5	6.0	15.1	2.4	0.2	0.0
7	8.2	4.0	6.6	38.5	2.6	10.9	5.4	19.8	3.8	0.2	0.0
8	14.1	5.3	7.2	43.5	2.2	9.8	4.8	10.9	1.6	0.1	0.0
9	8.4	3.1	7.4	51.2	3.0	10.4	5.5	9.8	0.8	0.0	0.0
10	40.9	1.6	3.5	32.4	1.1	6.4	3.5	9.3	1.1	0.0	0.0
11	38.2	0.4	1.0	16.5	1.2	12.7	12.1	17.2	0.7	0.0	0.0

Table 6 (continued): Analytical data for profile 207, Serskamp, East Flanders, Belgium

Horizon nr.	Mg++	Na+	K+	Ca++	CEC	BS	CEC/ clay	Al Dithi. Citrate	Fe Dithi. Citrate	Al Oxalate	Fe Oxalate
	----by NH_4OAc----										
	----cmol(+)/kg soil'----					%		%		%	
1											
2	13.24	0.40	5.43	36.88	61.9	90		0.083	0.226	0.009	0.024
3	2.63	<0.22	1.10	12.53	47.3	34		0.073	0.297	0.055	0.104
4								0.079	0.273	0.100	0.216
5	0.23	<0.22	0.15	0.86	9.3	13	44	0.145	0.265	0.096	0.282
6	0.17	<0.22	0.14	0.54	7.3	12	33	0.079	0.273	0.106	0.246
7	0.14	<0.22	0.12	0.41	7.9	8	32	0.213	0.351	0.117	0.221
8								0.246	1.025		
9	0.73	<0.22	0.03	1.22	2.0	99	20	0.213	0.351	0.065	0.188
10	2.97	<0.22	0.14	6.85	4.0	>100	9	0.246	1.025	0.095	0.539
11	1.90	<0.22	0.14	5.40	6.9	>100	17	0.155	0.159	0.050	0.061

Horizon nr.	Horizon symbols	Depth	Mg++	Na+	K+	Ca++	Al+++	Fe+++	Mn++	Free H+	Lab nr.
			----by $MgSO_4$ (compulsive method)----								
		cm	----cmol(+)/kg soil----								
1	OL	7-5									
2	OF	5-4	13.29	0.28	4.67	41.54	<0.19	<0.03	1.00	1.447	JM73
3	OH	4-0	3.31	0.10	1.62	18.65	0.78	0.14	1.92	3.343	JM74
4	Ah	0-2									JM75
5	Bhs	2-7	<0.12	<0.02	0.27	0.91	3.50	0.25	0.00	0.459	JM76
6	E	7-15	<0.12	<0.02	0.25	0.53	3.32	0.13	<0.002	0.220	JM77
7	Apb	15-30	<0.12	<0.02	0.23	0.41	3.56	0.10	<0.002	0.178	JM78
8	Btg	30-43									JM79
9	Btdg	43-71	0.57	0.03	0.11	1.23	0.89	<0.01	<0.002	2.414	JM80
10	2BCg	71-105	2.92	0.11	0.22	7.08	<0.04	<0.01	<0.002	0.035	JM81
11	2Cr	105-	1.78	0.05	0.26	5.61	<0.04	<0.01	<0.002	0.039	JM82

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
						----Aqua Regia----					
	cmol(+)/kg		%	cmol(+)/kg		----mg/kg----					
1											
2	65.0	40.2	>100	2.4	2.5	2934	14821	2003	165	1314	2069
3	29.9	20.8	>100	6.2	5.4	1346	2921	855	82	443	1365
4						2167	1085	1197	88	290	480
5	5.4	5.7	<22	4.2	4.2	2329	736	1337	76	138	166
6	4.4	4.8	<18	3.7	3.7	1997	670	1258	78	95	118
7	4.5	4.7	<15	3.8	4.0	2239	722	1385	96	112	154
8						2250	993	1539	207	77	140
9	5.2	3.8	<51	3.3	1.1	1636	889	1465	83	45	72
10	10.4	9.7	>100	0.0	<3.8	3903	1981	3003	157	43	49
11	7.8	7.8	<99	0.0	<3.8	3466	1713	2558	129	30	44

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	----Aqua Regia----									dS/m	
	----mg/kg----									1:5	%
1											
2	650	1.42	13.8	859	452	2	21.4	3.3	219	0.47	
3	5171	0.75	12.7	6704	70	11	79.5	6.8	86	0.22	
4	10749	0.32	7.1	9588	41	20	70.6	6.0	37	0.10	
5	11410	0.16	3.3	10927	35	21	57.3	4.2	23	0.05	
6	12375	0.12	2.4	10545	35	21	26.8	4.1	21	0.04	
7	12460	0.13	3.2	11236	38	22	18.3	4.2	28	0.04	
8	16161	0.14	2.5	9961	41	26	12.3	4.6	27	0.05	
9	11669	0.09	2.3	10200	35	20	5.8	5.2	20	0.04	
10	20176	0.20	12.7	25330	50	37	8.0	13.0	31	0.05	
11	15718	0.10	5.1	12894	34	31	5.7	11.7	25	0.04	0.9

The bulk density was analysed for 4 horizons (Table 7). In the E, the Apb and the Btg horizons the bulk density was 1.25-1.38 g/cm^3. In H9 (Btdg) the bulk density was as high as 1.73 g/cm^3 both before and after correction of stoniness (no coarse fragments were found).

The water holding capacity at field capacity is around 40% and at wilting point less than 5% remains (Table 7 and Figure 9). That implies that the soil can store a rather high content of plant available water. The deepest horizon has the highest water holding capacity especially for the lower pF values. Towards the wilting point all horizons analysed contains more or less the same quantity of water.

Table 8: Bulk density and water holding capacity for profile 207, Serskamp, East Flanders, Belgium. One sample was taken at the transition between H5 and H6.

Horizon nr.	Horizon symbols	Depth cm	Actual water content %	BDs soil g/cm3	BDFE fine earth g/cm3	Lab nr.
1	OL	7-5				
2	OF	5-4	19			JM73
3	OH	4-0	121			JM74
4	Ah	0-2	47			JM75
5	Bhs	2-7	25	1.38	1.38	JM76
6	E	7-15	24			JM77
7	Apb	15-30	26	1.25	1.25	JM78
8	Btg	30-43	26	1.36	1.36	JM79
9	Btdg	43-71	18	1.73	1.73	JM80
10	2BCg	71-105	22			JM81
11	2Cr	105-	21			JM82

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	----------	----------	----------	Vol. % water	----------	----------	----------	----------
1								
2								
3								
4								
5	59.0	50.3	48.8	43.9	40.9	26.8	22.4	3.8
6								
7	51.5	47.8	42.4	32.7	29.8	18.6	17.9	3.7
8	53.4	50.0	46.0	39.6	37.1	22.6	19.6	3.4
9	55.4	48.1	47.0	46.1	44.9	43.3	19.4	3.0
10								
11								

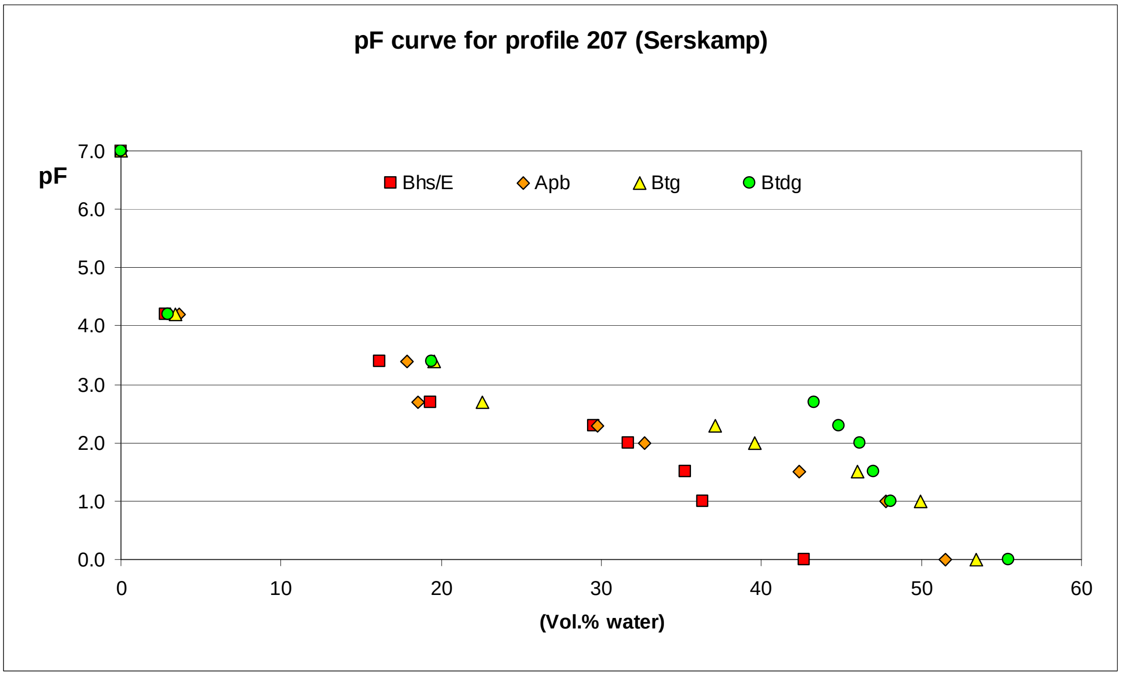

Figure 9: The pF curve for profile 207

4.3. Information deduced from the Belgian soil map

The forest site Serskamp is included on soil map Oordegem 71W (Louis and Tavernier, 1968) and makes part of the sandy loam region. The site is located in between an area dominated by alluvial deposits related to the Serskampse water stream (downslope) and tertiary deposits (upslope) that towards Serskamp village dips towards the surface. The experimental plot is enclosed in a soil map unit with code Ldc. More downslope it grades into Lep and towards west (poplar forest) Pdp. Upslope, including a tree nursery and further towards Serskamp, the soil units Sbc and Pbc are found (Figure 10). The map codes and their meaning are explained in Table 8.

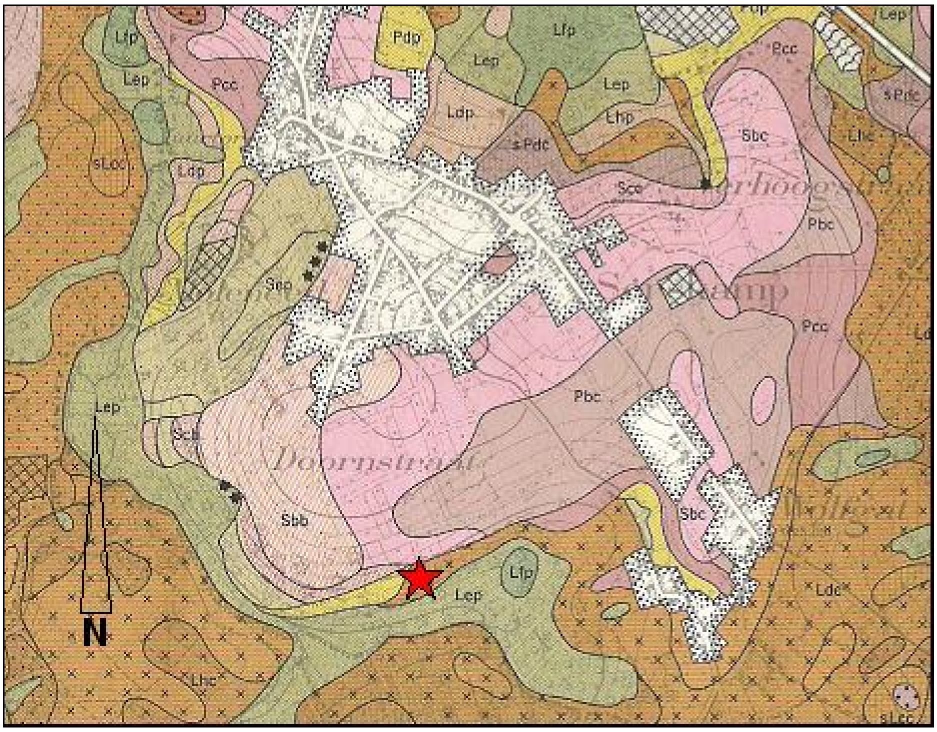

Figure 10: Soil profile P207 (red star) is located on soil map Oordegem 71W (Louis and Tavernier, 1968).

Table 9: Soil map units at and around soil profile 207, Serskamp. The information is deduced from Louis and Tavernier (1971)

Map unit	**Concise information:**
Ldc	Moderately well drained sandy loam soils with a strong mottled textural B horizon. The soils are hydromorphic degraded grey-brown Podzol like soil of the type Aquic Glossudalf (old American classification name; glossudalf means that tongues of bleached E horizon material is present into the underlying Bt horizon). Mostly the pedon is composed of an Ap horizon overlying a bleached E horizon and a Btg horizon, which at 50-80 cm depth shows strong influence of oxido reduction.
Lep	Poorly drained gleyic soils with a sandy loam texture and reduction horizon. Strong alluvial (or colluvial) soils with an Ap horizon overlying a Cg horizon. Due to a permanent groundwater table at about 80 cm depth, a reduction horizon (Cr) is present from here on. Very suitable for poplar (Louis and Tavernier, 1971).
Pbc	Dry sandy loam (towards loamy sand) soils with broken textural B horizon. These soils are strongly degraded Podzol like soils of the type Glossudalf
Pdp	Moderately well drained soils with a sandy loam (towards loamy sand) texture. These soils have no profile development except and Ap resting on top of the C horizon.
Sbc	Dry loamy sand soil with broken textural B horizon. The soils are described as strong degraded grey brown Podzol-like soils with a C horizon composed of green-brownish glauconitic sand.

4.4. Classification according to World Reference Base (2006)

While classifying this profile, incompleteness in the database was noticed. During the fieldwork bleached tongues were correctly observed and described in H9. Unfortunately only a composite sample was taken of the horizon. While analysing this sample, it appeared that it only contained 8.4% clay. This implies that it can not key out as an Argic horizon, which is requested for hosting Albeluvic tongues. Considering all morphological characteristics of H9, it is assumed that Albeluvic tonguing is present in this horizon. Most probably, if a separate sample had been taken of the matrix between the Albeluvic tongues, such sample would have had a clay content sufficiently high (>11.2%) to qualify for an Argic horizon. To summarise, P207 is classified assuming that the matrix in H9 between the Albeluvic tongues qualifies for an Argic horizon.

Diagnostic horizon, properties, material:	**Present in horizon**	**Remarks**
Albic		The bleached parts of H9 and H10 qualify, but the oxido-reduction mottles occupying 80% of the horizon are not.
Argic	H8-9	The composite sample of H9 does not have the required clay increase. By expert judgement it is assumed that a separate sample of the horizon matrix will qualify.
Abrupt textural change	Between H9-10	
Albeluvic tonguing	H9-10	The dry and moist colours are H9: 2.5Y 8/2 (D), 2.5Y 6/4 (M); and H10: 5Y 7/2 (D), 5Y 5/2 (M). All colours of the tonguing qualify for Albic. Separate data on texture from the tongues are not available.
Gleyic colour pattern	H10-11	H10: Oximorphic colours; H11: Reductomorphic colours
Lithological discontinuity	Between H9-10	
Reducing conditions	H5-11	
Stagnic colour pattern	H9	
Colluvial material	H5-6	Probably H6 and possible also H5. Material is originating from upslope agricultural fields. H7 has possible been ploughed a single time.

Simplified classification name
Stagnic Gleyic Albeluvisol

Full classification name without specifiers

Stagnic Gleyic Albeluvisol (Abruptic, Ruptic, Eutric, Siltic)

- Between H9 an H10 is a clay increase from 8.4% to 40.9%. Therefore both *Abrupt Textural Change* and *Lithological Discontinuity* qualify. The corresponding qualifiers are Abruptic and Ruptic. Considering that they are based on the same textural difference, it can be questioned if one of the qualifiers is redundant.
- Although most horizons are Dystric, the major part of the soil between 20 and 100 cm depth is Eutric
- Siltic: The soil has a silt loam texture from H6-9. Notice that for this qualifier the soil surface is the begin point, which implies that the litter layer should be included
- Colluvic is not a listed qualifier

BioSoil classification name (WRB 2006), with specifiers

Epistagnic Endogleyic Albeluvisol (Endoabruptic, Endoruptic, Eutric, Endosiltic)

- Eutric is not added as a depth specifier because H9 starts exactly at 50 cm depth and data on H8 are missing.

4.5. Discussion

Profile 207 Serskamp is characterised by a degraded B horizon characterised by bleached tongues, clay migration and oxido reduction mottles. The deepest horizon appears with completely reduced colours.

In the field H7 was interpreted as the original A horizon, which most probably had been ploughed at least once. If indeed the soil has been ploughed this must date from before the forest was planted. Afterwards colluvium accumulated on top of H7.

When the particle size distribution of H5-6 is compared with H7, a very similar distribution is observed. Other chemical parameters are also very similar between the colluvium and the buried surface horizon. This suggests that the colluvium comes from a similar type of soil and from the same level within the pedon meaning that somewhere upslope the original A horizons has been eroded and accumulated on top of this soil. A logical explanation would be that right after the soil had been ploughed erosion/sedimentation took place before any new vegetation could provide sufficient protection. Upslope from the forest a tree nursery occupies the area. For the sake of optimal growth between the rows of seedlings, the soil is kept without vegetation. Erosion from such bare soil can also be a source of colluvial material.

The soil has very good physical properties, with sufficient clay and silt to maintain a good water holding capacity. The presence in depth of a substratum with high clay content assures that leaching of nutrients is considerably slowed down. The content of basic cations and other elements making up the fertility of the soil is moderately low.

With the necessary expert judgements, the soil keyed out in Albeluvisols, which seems correct, but the soil did not have any Fragic horizon characterising for example Albeluvisols of the Zonien forest.

Although the Belgian soil classification name given in 1993 did recognise the strongly broken character of the texture B horizon, the given FAO (1988) soil classification name was 'Stagnic Alisols'. In 1993 the soil surveyors opted for 'Stagnic' properties and not for 'Gleyic' since this was observed in four of the five augerings (Roskams, 1995).

5. Profile 404, Binkom-Lubbeek, Flemish Brabant

5.1. Site and profile description

Profile 404	**Binkom-Lubbeek (Level 1 forest plot)**
1.2 Date of description:	8/5/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Flemish Brabant, Lubbeek Municipality. Where the Tiensesteenweg (N223) runs through the village Binkom, take on the western side the narrow paved road Keiberg. After 300 m, the road transforms into a field dirt road, which further downhill becomes a hollow road. After about 300 m along the dirt road on the left side the beech-oak forest stand appears (photo 9). The level I forest plot is situated in a forest, probably of several owners and with very different vegetation and management. The total size of the forest is about 25 ha.
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 55 *Code profile:* 404 *Latitude, longitude:* 50° 52' 24.91" N, 4° 52' 24.86" E
1.6 Elevation:	80-82.5 m a.s.l.
2.1 Atmospheric climate and weather condition:	Overcast, with a bit of rain within the past 24 hours.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The forest stand is located in a gently undulating landscape characterised with altitudes within the range of 50-100 m. The forest plot is part of the catchment area of the Molenbeek tributary, located about 500 m to the west of the forest plot (figure 10, 11 and 12). *Meso topography:* The forest floor is locally dominated by surface compaction and deformation due to the impact from heavy machinery (forest exploitation). The profile is located on a gentle slope and is constructed with the long axis parallel to the ditch direction (photo 11). *Landscape position:* Upper slope in concave position *Slope form:* SS (straight, straight) *Slope gradient:* sloping, 7.8% (3.5°) *Slope length:* The general slope is about 1.5 km long and ends at the brinks of the Molenbeek. *Slope orientation:* dipping towards NW
2.4 Land-use:	Plantation forestry with selective felling. Poor natural regeneration. *Wildlife:* not protected *Grazing:* none, except by roe deer
2.5 Human influence:	Vegetation slightly disturbed. Forest is planted.
2.6 Vegetation:	Deciduous forest

Tree layer		**Shrub layer**		**Herb layer**	
Northern Red Oak	*Quercus rubra*	Black Cherry	*Prunus serotina*	Northern Red Oak	*Quercus rubra*
		Northern Red Oak	*Quercus rubra*	European Beech	*Fagus sylvatica*
		Sycamore Maple	*Acer pseudoplatanus*	Brambles	*Rubus sp.*
		Sweet Chestnut	*Castanea sativa*		

2.7 Parent material:	Loamy loess (7110)
2.8 Drainage class:	Moderately well drained *Availability of water:* sufficient
2.9 Internal drainage:	Rarely saturated (few days in some years)
2.10 External drainage:	Slow run-off

2.12 Groundwater:	No water table observed, probably extremely deep (>2m)
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	Few gravels at the contact between mineral soil and the forest floor.
2.15 Erosion, sedimentation:	Erosion related to human activities, occupies 0-5% of the surface. The degree of erosion is slight (some evidence of damage to the topsoil) The erosion is active at present, e.g. at the level of the forest road.
2.17 Surface cracks:	Irregular fine (<1 cm) polygonal cracks at the surface of the mineral soil
Humus classification:	Following horizon sequence according to the humus classification system was observed (photo 10): OLn: fresh organic material; OLv, slightly altered organic matter; OFz: fragmented leaves; OHz: continuous but <1 cm thick; many roots; Aze: sharp delineation towards the OH horizon; transition to B-horizon is gradual. *Classification name:* Moder → subdivision: Eumoder
Remarks:	"bi" is a symbol applied for biologically active horizons, not applicable for A

No.		**Horizon description** (see also photo 12)
H1	OL	-8 till -5 cm; at lower part of OLn common mast (oak seeds); lower ½-1 cm is the OLv horizon
H2	OFz	-5 till -1 cm; dark brown 10YR 3/3 (M)
H3	OHz	-1-0 cm; very dark brown 7.5YR 2.5/2 (M); some faunal activity although no earthworms are observed; few macro faunal galleries, diameter ± 1 cm; few gravels at the contact to H4;
H4	Ad/Aze	0/6-2/9 cm; very dark grey 10YR 3/1 (M), very dark greyish brown to dark greyish brown 10YR 3.5/2 (D); positive reaction to α,α-dipyridyl, throughout; one single, angular, fresh, fine gravel sized silex observed; massive (compaction of surface by heavy machinery), locally granular; very friable; medium porosity; very few, very fine, hard, manganese oxide, black nodules, and very few, fine, hard, brown, iron-manganese oxide fragments; common very fine to fine, few medium and very few coarse roots; irregular polygonal cracking system in the upper part, cracks filled with material from H3; abrupt, wavy boundary
H5	EB	2/9-8/12 cm; yellowish brown 10YR 5/4 (M), to very pale brown 10YR 7/4 (D); positive reaction to α,α-dipyridyl, throughout; no gravel; massive, locally platy (due to surface compaction); very friable; very few, fine, hard, brown, iron-manganese fragments; few very fine to fine roots; clear, smooth boundary
H5b	Pocket	6-13 cm; humeferous pocket, possible an old wheel track; dark greyish brown; positive reaction to α,α-dipyridyl throughout; very friable; no roots observed; abrupt, broken boundary
H6	Ebi	8/12-21/27 cm; yellowish brown 10YR 5/5 (M); very pale brown 10YR 7/4 (D); few (2-5%), coarse, distinct, clear, bleached mottles in lower part of horizon; positive reaction to α,α-dipyridyl, throughout; silt loam; very few, flat and rounded, fresh and slightly weathered, fine to medium gravels; massive; very friable; high porosity; vertical macro pores, diameter ± 1cm; common very fine and very few fine to coarse roots; abrupt, wavy boundary
H7	Bwbi	21/27-36/44 cm; yellowish brown to light yellowish brown 10YR 5.5/4 (M); very pale brown 10YR 7/4 (D); positive reaction to α,α-dipyridyl, throughout; silt; very few, sub-rounded and rounded, fresh to slightly weathered, fine gravels; weak, incomplete angular blocky; very friable; high porosity; common very fine and very few fine to coarse roots; abrupt,

		smooth boundary
H8	Eg	36/45-50/67 cm; horizon composed of bleached tongues; light yellowish brown 10YR 6/4 (M); very pale brown 10YR 7/3 (D); positive reaction to ɑ,ɑ-dipyridyl, throughout; silt; incomplete, moderately developed, coarse angular blocky; very friable; very high porosity; very few, very fine to fine roots; broken, irregular boundary
H9	Btgd	36/44-54/68 cm; horizon composed of bleached mottles and tongues with colours: light yellowish brown 10YR 6/4 (M), very pale brown 10YR 7/4 (D); light yellowish brown to brownish yellow 10YR 6/5 (MC); and many (15-20%) medium to coarse, diffuse, distinct, strong brown to dark yellowish brown 8.5YR 4/6 (M) mottles; positive reaction to ɑ,ɑ-dipyridyl, throughout; silt loam; no gravel; incomplete, moderately developed, medium angular blocky; very friable; high porosity; very few, very fine to fine, soft, manganese oxide black nodules, present only in upper 8-10 cm of horizon; very few very fine to fine roots; clear, wavy boundary
H10	Btgx	54/68-78/85 cm; yellowish brown 10YR 5/5 (M); yellowish brown to brownish yellow 10YR 6/5 (D); many (50-60%), coarse, prominent, clear to diffuse, dark yellowish brown 10YR 4/6 (M) mottles (correspond to inside peds), bleached parts of horizon have light yellowish brown 2.5Y 6/3 (M) mottles and interfingerings (between and on surface of peds); positive reaction to ɑ,ɑ-dipyridyl throughout; silt loam; no gravel; moderately developed, incomplete angular blocky; friable; medium porosity; no clay coatings observed; very few very fine and fine roots; gradual, smooth boundary
H11	2BCg	78/85-114 cm; yellowish brown to light olive brown 1.5YR 5/4 (M); brownish yellow 10YR 6/6 (D); dark yellowish brown to yellowish brown 10YR 4.5/6 (M) mottles, and many (20-30%) coarse, prominent, diffuse, light yellowish brown 2.5Y 6/3 (M) mottles and interfingerings; no reaction to ɑ,ɑ-dipyridyl; sandy loam; many (±30% by vol.), sub-rounded, rounded and angular-fragmented, fresh, medium to coarse gravels, few with soil cappings; incomplete, weak to moderately developed, very coarse angular blocky; very friable; medium porosity; very few very fine roots; gradual, smooth boundary
H12	2CBg	114-150 cm; yellowish brown 10YR 5/6 (M); brownish yellow 10YR 6/6 (D); 10YR 5/6 (M) mottles, and common (10-15%), coarse, prominent, diffuse, light yellowish brown 2.5Y 6/3.5 (M) mottles; low porosity; no reaction to ɑ,ɑ-dipyridyl; sandy loam; many, sub-rounded, rounded and angular-fragmented, fresh, medium to coarse gravels, some with soil cappings; massive; very friable; very few, very fine roots; clear, smooth boundary
H13	3Cr	150-… cm; light yellowish brown 2.5Y 6/3.5 (M); pale yellow 2.5Y 7/3 (D); no reaction to ɑ,ɑ-dipyridyl; sand; no stones; massive; loose; very low porosity; no roots

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Photo 9: The forest plot. Entering the forest the level I plot is located about 150 from the forest edge (Photo JM).

Figure 11: Topographical map around profile 404-Binkom-Lubbeek in the province of Flemish Brabant. The distance from west to east is 6600 m (NGI, 2002, map 103)

Figure 12: Orthophotographical view on the study area. The distance from west to east is 1935 m (Eurosence, 1991, map Lubbeek 32/3/2)

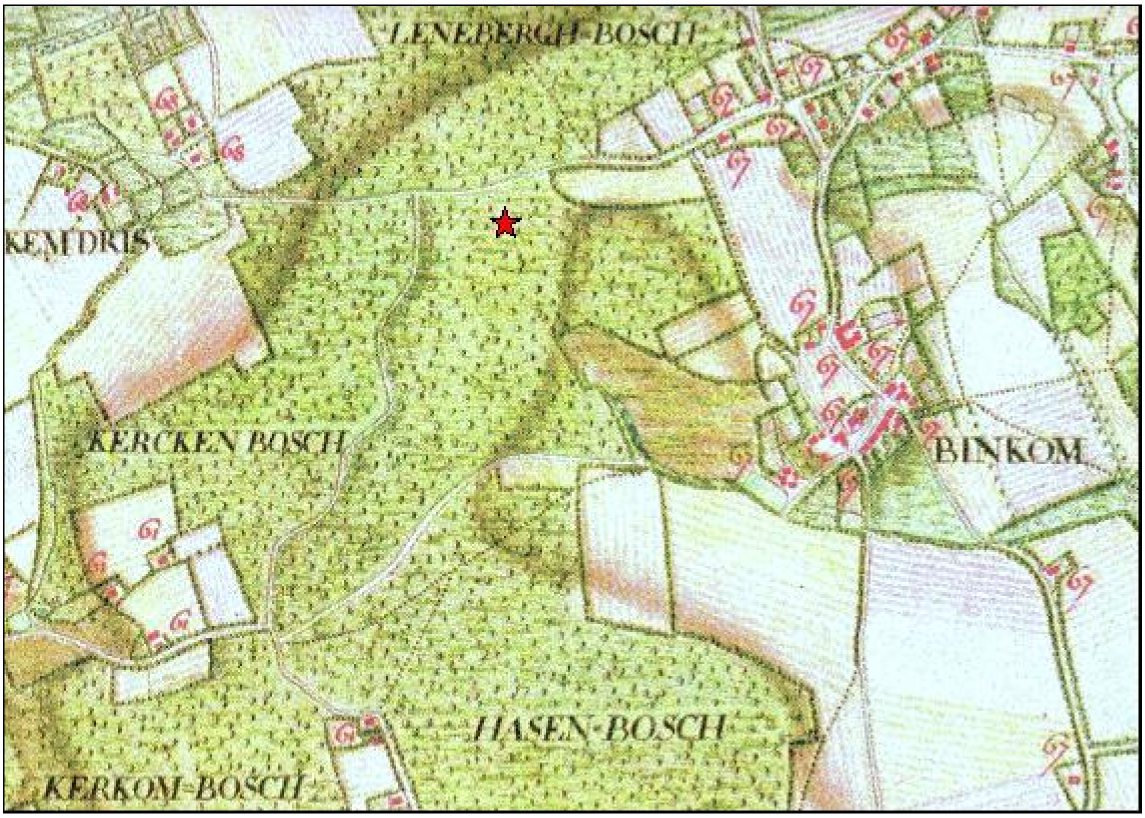

Figure 13: Cut out of the Ferraris map of Lubbeek (Ferraris, 1777, map nr. 111/4). The distance from west to east is 2560 m.

Photo 10: The rather thin humus layer with a relatively sharp border to the mineral soil (Photo JM)

Photo 11: The forest vegetation in the immediate surroundings of soil profile P404 (Photo JM).

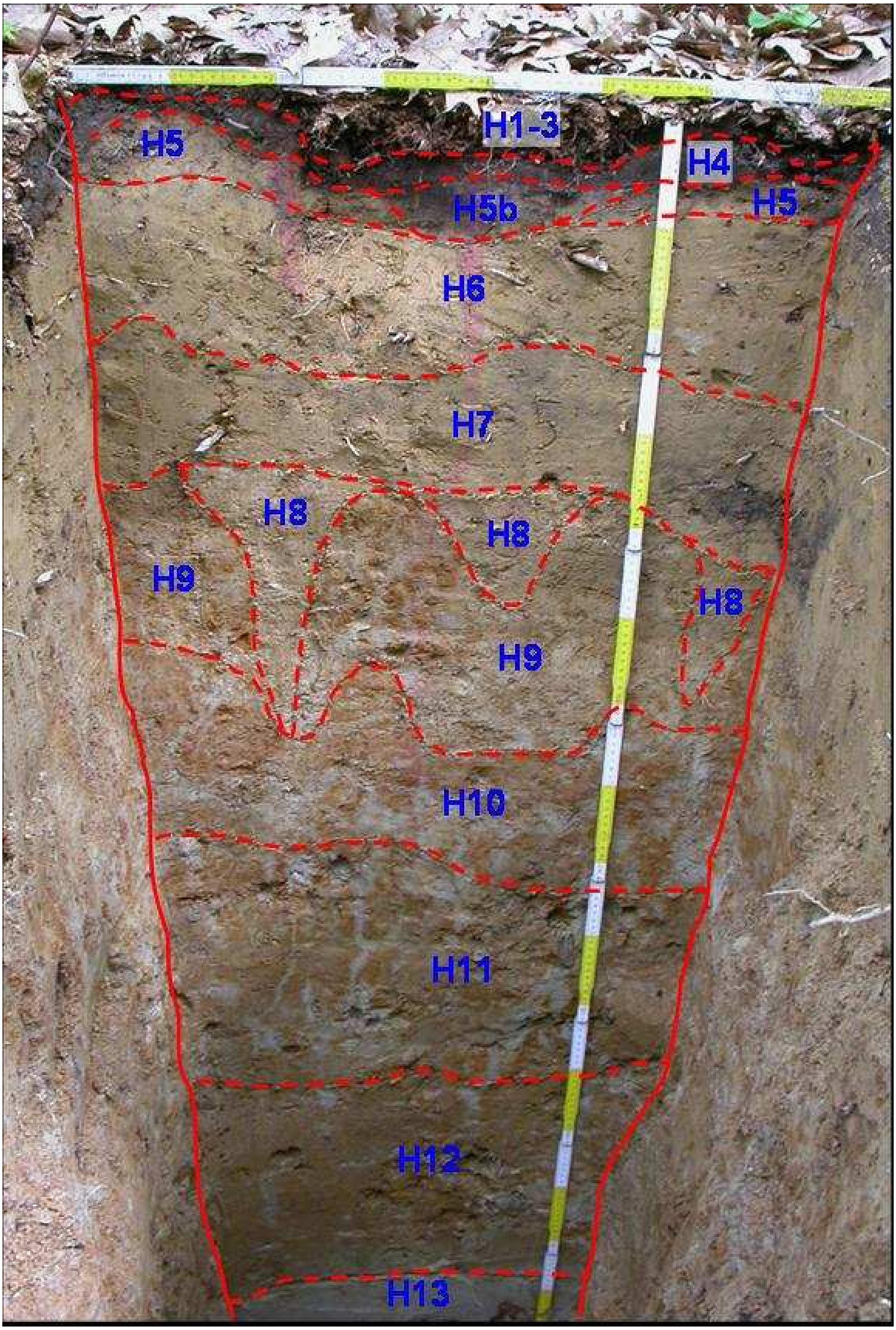

Photo 12: Soil profile P404.

Photo 12 shows in the top a loose soil (H1-5) where roots can grove overlying a root restricting subsoil interfingered by bleached tongues (H6). In the subsoil some stagnic problems arise because of reducing conditions along pores, fractures and tongues with oxidised conditions inside the peds (Photo JM).

5.2. Analytical data

The data in Table 9 show that the organic layers have high C/N ratios. Through the mineral soil the C/N ratio drops from 18 to 4. In general the content of both nitrogen and organic carbon in the mineral soil is rather low except for a 5 cm thin Ah horizon. The pH is acid (4.0-4.2) with a slightly higher pH in the deepest horizons. A very small content of coarse fragments (0.4-0.9%) found in the upper mineral horizons is composed mostly of coarse fragmented organic matter. In H11-12 a content of coarse fragments of 14.6-27.9% was measured. In H10 the content of gravels is 0%, which indicates the presence of a lithological discontinuity. On the larger gravels and stones soil cappings were observed in the field. Normally soil cappings develop if the soil is undergoing freeze/thaw sequences, but the gravelly horizons starts at 80 cm depth. Today the climate in Belgium is too warm that the soils would repeatedly become frozen to a depth of 80 cm during the winter. Either the soil cappings were formed during a past colder climate, or they were formed when the stony layers were located closer to the surface meaning before the loess had deposited on top.

Table 10: Analytical data for profile 404, Binkom-Lubbeek, Flemish Brabant, Belgium. Profile studied 8/5/2006. Profile analysed: 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Total N (Kjeldahl) Standard %	Org. Carbon TOC %	Org. Carbon W&B %	OM LOI %	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm %-wght
1	OLn	8-5									
2	OFz	5-1	1.488				78		4.4	3.8	
3	OHz	1-0	1.423				62		4.0	3.0	0.0
4	Ad	0-5	0.683	0.690	12.14	8.8					0.9
5	EB	5-10	0.063	0.067	1.06	0.7					0.4
5b	pocket	6-13									0.0
6	Ebi	10-24	0.053	0.062	0.68	0.7			4.1	3.8	0.0
7	Bwbi	24-37	0.052	0.055	0.56	0.6			4.1	3.8	0.0
8	Eg	37-50/67	0.042	0.036	0.30	0.3			4.2	3.8	0.0
9a	Btgd1	37-60	0.052	0.045	0.23	0.2			4.2	3.7	0.0
9b	Btgd2	37-60			0.28	0.3			4.1	3.6	0.0
10	Btgx	60-81			0.20	<0.1			4.0	3.6	
11	2BCg	81-114			0.10	<0.1			4.5	3.7	14.6
12	2CBg	114-150			0.07	<0.1			5.4	4.2	27.9
13	3Cr	150-…			0.03	<0.1			4.7	4.0	tr

Horizon nr.	Particle size distribution (fractions in µm) 0-2 %	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
1											
2											
3											
4											
5											
5b											
6	12.3	7.9	15.1	55.1	1.8	2.8	1.0	2.7	0.5	0.3	0.4
7	10.7	6.7	10.8	61.7	2.1	2.9	1.1	2.9	0.5	0.3	0.2
8	10.4	7.4	11.7	60.3	2.3	3.0	1.0	2.5	0.5	0.3	0.3
9a	15.5	7.5	13.3	55.4	1.7	3.0	0.9	1.9	0.4	0.2	0.1
9b	17.6	6.1	9.1	60.0	2.0	2.4	0.6	1.6	0.3	0.1	0.0
10	17.8	7.0	11.2	54.9	2.6	2.9	1.0	2.1	0.2	0.0	0.0
11	12.0	2.5	2.4	20.3	2.3	7.6	7.8	31.3	10.4	2.6	0.5
12	10.0	1.9	1.1	10.7	1.2	6.2	11.2	38.6	10.1	6.2	2.9
13	3.4	0.5	0.2	2.9	0.6	5.3	19.3	66.6	0.9	0.0	0.0

Horizon nr.	Mg^{++} (by NH_4OAc, cmol(+)/kg soil)	Na^+	K^+	Ca^{++}	CEC	BS %	CEC/clay	Al Dithi. Citrate %	Fe Dithi. Citrate %	Al Oxalate %	Fe Oxalate %
1											
2	3.51	0.28	1.88	18.60	53.7	45				0.026	0.039
3	1.08	0.21	1.03	5.58	61.9	13				0.115	0.105
4	0.64	0.08	0.34	0.65	30.1	6					
5	0.13	0.02	0.10	0.25	8.6	6					
5b											
6	0.20	0.04	0.10	0.04	6.8	6	36	0.188	0.473	0.154	0.463
7	0.18	0.03	0.09	0.05	6.5	5	43		0.368	0.148	0.425
8	0.18	0.03	0.09	0.06	5.9	6	47		0.342	0.142	0.440
9a	0.22	0.04	0.14	0.09	3.4	15	17		0.436	0.171	0.449
9b	0.24	0.03	0.10	0.13	5.2	10	24		0.543	0.182	0.406
10	0.35	0.07	0.18	0.26	6.6	13	33		0.686	0.201	0.673
11	0.50	0.06	0.15	0.58	2.8	47	20		0.309	0.128	0.429
12	1.14	0.07	0.18	1.28	6.1	44	58		0.360	0.117	0.677
13	0.39	0.04	0.05	0.40	2.0	44	56		0.031	0.027	0.017

Table 9 (continued): Analytical data for profile 404, Binkom-Lubbeek, Flemish Brabant, Belgium. Profile studied 8/5/2006. Profile analysed: 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth	Mg++	Na+	K+	Ca++	Al+++	Fe+++	Mn++	Free H+	Lab nr.
			by $MgSO_4$ (compulsive method)								
		cm	cmol(+)/kg soil								
1	OLn	8-5									JM83
2	OFz	5-1	4.47	0.13	1.80	24.01	<0.17	<0.03	3.334	2.50	JM84
3	OHz	1-0	1.27	<0.09	0.90	6.88	5.69	0.39	0.666	5.98	JM85
4	Ad	0-5									JM86
5	EB	5-10									JM87
5b	pocket	6-13									
6	Ebi	10-24	<0.12	<0.02	0.08	<0.02	4.14	0.03	0.013	0.14	JM88
7	Bwbi	24-37	<0.12	<0.02	0.08	<0.02	3.64	0.01	0.007	0.10	JM89
8	Eg	37-50/67	<0.12	<0.02	0.08	0.04	3.44	<0.01	0.017	0.12	JM90
9a	Btgd1	37-60	<0.12	<0.02	0.12	0.07	4.48	<0.01	0.060	0.12	JM91
9b	Btgd2	37-60	<0.13	0.02	0.14	0.13	5.50	<0.01	0.007	0.13	JM92
10	Btgx	60-81	0.13	0.05	0.16	0.25	5.93	<0.01	0.009	0.12	JM93
11	2BCg	81-114	0.41	0.04	0.17	0.59	3.84	0.22	0.026	0.19	JM94
12	2CBg	114-150	1.06	0.05	0.18	1.38	0.57	1.33	0.145	0.86	JM95
13	3Cr	150-…	0.28	<0.02	0.07	0.41	0.76	<0.01	0.014	0.11	JM96

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
						Aqua Regia					
	cmol(+)/kg		%	cmol(+)/kg		mg/kg					
1						1446	7297	1236	110	454	1136
2	36.2	28.6	>100	5.8	4.0	1226	5957	936	101	729	1783
3	21.8	24.4	<37	12.7	12.5	1187	1759	726	89	611	1898
4											
5											
5b											
6	4.4	4.8	<3	3.7	4.5	2539	934	1904	141	90	116
7	3.8	4.3	<4	3.5	4.0	2115	778	1760	119	81	119
8	3.7	4.2	<4	4.6	3.7	2587	975	1986	135	87	103
9a	4.8	5.8	<4	5.6	4.9	3792	716	2990	158	123	120
9b	5.9	7.1	<5	6.2	6.1	4638	965	3465	173	109	98
10	6.6	7.7	8	4.7	6.6	4986	987	3941	176	169	119
11	5.5	6.2	19	3.4	4.4	4618	479	2769	114	132	99
12	5.6	5.5	49	1.2	1.8	3816	505	2241	85	126	85
13	1.6	<4	<39	0.0	1.0	1762	224	993	40	38	36

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	Aqua Regia									dS/m	
	mg/kg									1:5	%
1	683	0.33	6.8	825	1787	2	9.1	2.6	57		
2	2404	0.67	11.9	3110	1796	6	33.5	5.0	82	0.30	
3	6152	0.68	14.2	6925	315	11	108.9	8.8	84	0.09	
4										0.12	
5										0.06	
5b											
6	17935	0.17	4.5	15675	173	29	15.2	7.6	33	0.03	
7	15970	0.16	3.6	14713	209	24	12.3	6.9	31	0.03	
8	17085	0.17	4.8	14244	201	27	8.7	8.3	34	0.03	
9a	22299	0.37	8.2	22479	464	33	10.0	13.1	46	0.03	
9b	25630	0.43	8.7	25979	106	40	9.3	13.1	44	0.04	
10	26806	0.46	8.8	27490	169	42	12.2	16.0	50	0.04	
11	16903	0.40	7.3	23098	100	38	7.2	13.3	36	0.02	
12	13781	0.38	7.9	21240	159	48	6.6	23.2	32	0.01	
13	5832	0.10	2.1	5593	51	14	3.0	5.3	20	0.02	

H6-10 has a very homogeneous particle size distribution despite of the clay content as a clay increase is observed in H9-10. This clay increase is linked with clay migration, a process that is inactive today as clay migration is possible only when the soil has a pH of about 6-6.5.
H11-12 are two horizons with a less silty and a more sandy texture. Especially the content of coarse silt has undergone a dramatic drop compared with the horizons above (from 55-60% to 10-20%). Instead the fraction fine sand (125-250 µm) has increased from about 2% to 31-38%. Evidently these changes in the particle size distribution indicate the presence of a lithological discontinuity. A second lithological discontinuity is observed between H12 and H13, as in H13 the content of clay drops to 3%, very little silt is present and the content of fine sand increases to 66%. What is observed is that first sandy sediment was deposited followed by a transition period wherein both silt and sand accumulated before the deposition material became more loess like.

This is an example of a forest soil where the basic cations are nearly entirely stored in the organic topsoil. From the surface of the mineral soil to a depth of 80 cm the content of basic cations is very small. This trend is best illustrated by the base saturation, which is 45% in the

OF horizon, drops to 13% in the OH horizon and is only 5-6% in the upper mineral horizons . From 40-80 cm the base saturation is 10-15% and from 80 cm it increases to 44-47%.

The aluminium saturation remains above 89% for H6-10, but also in the deeper horizon a considerable part of the cation exchange capacity is occupied by aluminium. Despite the presence of aluminium oxides tree roots gain an advantage if they reach the deeper more nutritious and less acid substratum.

A slight peak in the content of oxalate and dithionite extractable iron is found in H10, which is the Btgx horizon. Possibly, this enrichment is due to iron that has been migrating with the clay combined with local oxido reduction depletion and precipitation. The content of iron and aluminium elements measured according to the method of aqua regia is high though not exceptionally high. Values of 2-3% are found in H9-11.

The bulk density is normal and remains stable through the analysed horizons (Table 10). The water holding capacity is 40-45% at field capacity and only 2.5-5.7% at wilting point. That implies that the soil is able to store about 35-40% water in the plant available range, which is rather good (Table 10; Figure 14).

Table 11: Bulk density and water holding capacity for profile 404, Binkom-Lubbeek, Flemish Brabant, Belgium.

Horizon nr.	Horizon symbols	Depth cm	Actual water content %	BD_S soil g/cm3	BD_{FE} fine earth g/cm3	Lab nr.
1	OLn	8-5	16			JM83
2	OFz	5-1	71			JM84
3	OHz	1-0	146			JM85
4	Ad	0-5				JM86
5	EB	5-10				JM87
5b	pocket	6-13				
6	Ebi	10-24	20	1.35	1.34	JM88
7	Bwbi	24-37	23	1.35	1.35	JM89
8	Eg	37-50/67	22			JM90
9a	Btgd1	37-60	19	1.37	1.37	JM91
9b	Btgd2	37-60	24			JM92
10	Btgx	60-81	22	1.41	1.41	JM93
11	2BCg	81-114	14			JM94
12	2CBg	114-150	8			JM95
13	3Cr	150-…	18			JM96

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	---- Vol. % water ----							
1								
2								
3								
4								
5								
5b								
6	53.4	44.6	42.2	40.6	38.8	36.7	17.5	3.5
7	52.3	42.0	40.3	39.1	37.7	36.8	15.0	2.4
8								
9a	55.0	47.1	45.7	44.7	43.2	42.3	21.9	5.7
9b								
10	55.4	46.6	45.2	44.2	42.8	41.9	20.2	4.9
11								
12								
13								

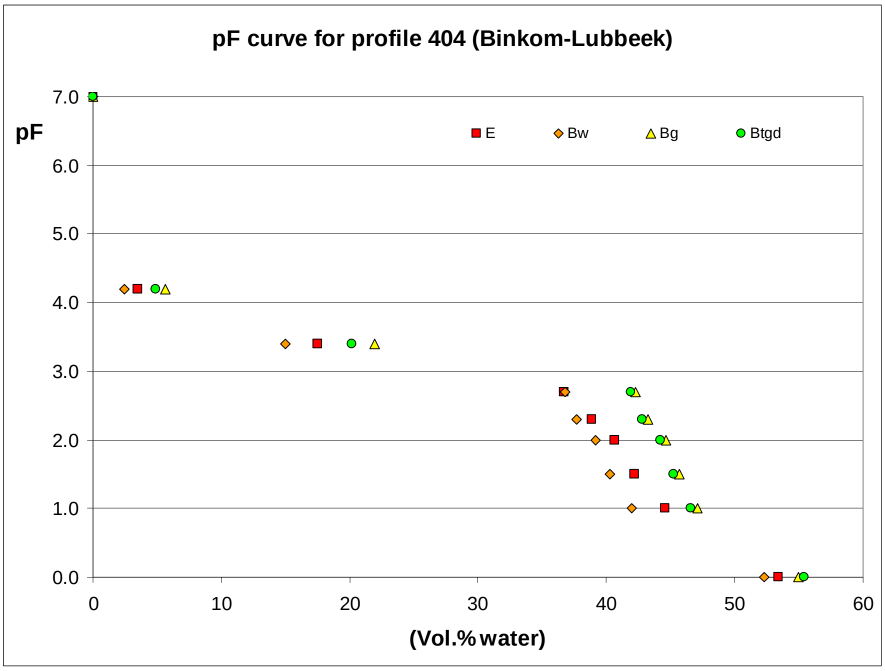

Figure 14: The content of water for profile 404 in function of different pF values

5.3. Information deduced from the Belgian soil map

Profile plot 404 is located on soil map Lubbeek 90W (Scheys and Tavernier, 1956), covering an area dominated by silty (loess) and loamy soils. Within this map 3 soil regions are recognised, these are:

1) The gently undulating loess region. Located on the South-eastern part of the map, about 12.5 km to the south of soil profile 404. In this region the soils are of the loess type, and morphologically belong to the "Brabantse en Haspengouwse" loess regions. Towards the north the region is limited by the tributary valley of the Velp.
2) The central gently undulating loamy region. Located in the central part of the map and including the area of the soil profile. The geological substratum is the Tongerian, which is a fluvio-marine coarse sandy or gravely substratum.
3) The northern undulating loamy region. The northern region is underlain by Diestian sand, which is a geological substratum characterised by greenish glauconite rich sands, although towards the surface it is increasingly reddish due to weathering. See also following profile P406, Deurne.

The typical soil horizon sequence found in loess and loamy soils of soil map Lubbeek 90W, and developed below forest vegetation, is as follows:

- Ah: humus enriched top soil,
- E: clay depleted yellowish brown silty horizon, about 40-50 cm thick,
- Bt: clay enriched brown to dark brown horizon with blocky structure and a thickness of about 50-60 cm,
- BC: yellowish-brown silty horizon with a weak angular blocky structure, varying thickness
- C: yellow or greyish-yellow, loose carbonate rich loess horizon.

Profile 404 is on the soil map located on the border between map unit Lda and Lhc (Figure 15). Uphill (towards east) soils of the type SAfd dominate and on the other side of the field road (towards north) the soils are of the uLda type. Also within short distance of the profile soils are mapped as UDx. A short definition of these soil units are presented in Table 11. Sandy silt and light sandy silt are Belgian texture classes, which contain 15-68% sand and at most 17% clay. Sandy silt corresponds roughly to loam and silt loam, light sand silt would make up the more silty part of the sandy loam texture class. Morphologically soil profile 404 is a sAdc profile according to the Belgian soil classification. The 's' stands for a shallow sand substratum, the 'A' refers to the silty texture (loess), 'd' is insufficiently drained and 'c' the soil horizon development (soils with a strongly mottled clay illuviation horizon).

Table 12: Concise description of the soil map units in the immediate vicinity of soil profile 404 (after Scheys and Tavernier, 1957)

Map unit	Definition
Lda	Moderate gleyic sandy silt soils with a Bt horizon
uLda	As Lda, but with clay substratum starting at shallow depth (40-80 cm)
Lhc	Strong gleyic sandy silt soils with a strong mottled Bt horizon
SAfd	Dry till moderate wet silty sand soils, with weak humus and/or iron B horizonation. Variants with either yellowish or greenish subsoil's.
UDx	Weak to moderate gleyic heavy clay soils with no clear profile development
sAdc	The visited soil profile

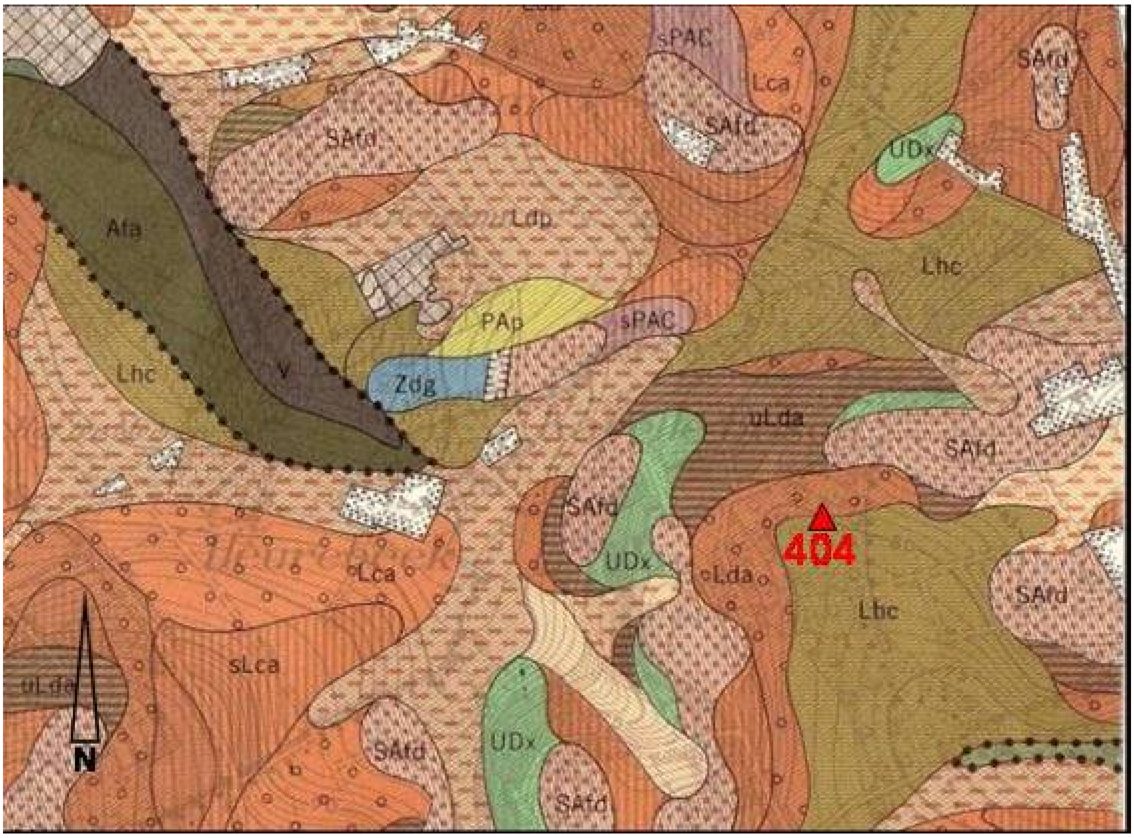

Figure 15: Detailed part of soil map 90W with profile 404 indicated. The distance from west to east is 1960 m (Scheys, 1956).

5.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material:	Present in horizon	Remarks
Albic	H8	
Argic	H9-10	Most probably clay coatings are present, but the soil was too wet at the moment of description to observe them.
Fragic	H9-10	The measured penetration resistance was only 3.5 MPa, far from the required 5 MPa.
Albeluvic tonguing	H8	
Gleyic colour pattern	H13	Reductomorphic colours
Lithological discontinuity	Between H10-11 Between H12-13	Between H10 and H11 (increase in 125-250µm fraction from 2.1% to 31.3%). Presence of stones in H11-12 Second lithological discontinuity between H12 and H13, based on a strong change in content of 125-250µm sand, and absence of stones in H13.
Reducing conditions	H4-10	
Stagnic colour pattern	H10-12	Mottles most pronounced in H10, less in H11 and least in H12

Simplified classification name
Stagnic Cutanic Albeluvisol

Full classification name without specifiers
Stagnic Cutanic Albeluvisol (Ruptic, Alumic, Dystric, Siltic)

BioSoil classification name (WRB 2006), with specifiers
Endostagnic Cutanic Albeluvisol (Endoruptic, Hyperalumic, Hyperdystric, Siltic), [Hypofragic] • A Fragic is not present, but we can include it as Hypofragic, indicating it is a weakly developed version of a Fragic horizon. The Hypofragic is written at the end of the classification name between a second set of brackets

5.5. Discussion

Profile 404 belongs to the region of sandy loamy soils. The profile is composed of a rather thin humus rich topsoil with a loose light brown coloured B horizon (H5-7) resting on top of a dense Bt horizon characterised by bleached tongues. Further in depth oxido reduction has coloured a series of horizons. Roots are largely restricted to the upper loose light brown horizons. As these horizons are also the most nutrition depleted ones, this is a poor soil for plant growth if the deeper dense horizons are not broken.
The soil keys out in Albeluvisols which is a classification that fits perfect with the morphological characteristics of this soil. The root restriction caused by the dense horizons, which is a very limiting aspect of this soil for plant growth, is not dense enough for the qualifier Fragic. As roots are prevented from growing from around 3-3.5 MPa, the diagnostic limit on penetration resistance for Fragic horizons should be lowered to 3.5 MPa to comprehend properly to the problems for root penetration. Until then the specifier “hypo” for any horizon that fulfil all

diagnostic requirements for a Fragic horizon but has a penetration resistance between 3.5 and 5.0 MPa is applied. If tests shows that roots are restricted already if the soil has a penetration resistance of 3.5 Mpa, why is the requirement for Fragic then maintained at 5.0 Mpa? Redefining this qualifier and lowering the penetration resistance has in the meantime been executed by the WRB working group. In the corrected version of the World Reference Base (WRB-2007) the penetration resistance has been lowered to 4.
In fact several of the diagnostic criteria for Albeluvisols are difficult to check in the field or demand a very great effort in order to collect all information. This may influence the quality of the database whereby many Albeluvisols will be based on expert judgements in lack of all data, or simply become classified as other soil reference groups than Albeluvisols.

In 1993, the soil type of this plot was described as 'Stagnic Alisols' (FAO, 1988). So based on the FAO name, it seems that the tonguing nature of the upper boundary of the B horizon was not recognised. The classification in 1993 was based on soil auger observations where it is nearly impossible to recognise and/or quantify the albeluvic tonguing. On the other hand, the Belgian soil classification name of this plot did recognise the broken character of the texture B horizon (Roskams, 1995). So the differences in major soil reference group between 1993 and 2006 might be rather attributed to incorrect correlation between national and international classification systems than due to different interpretations in the field.

6. Profile 406, Deurne, Flemish Brabant

6.1. Site and profile description

Profile 406	**Deurne 1 (Level 1 forest plot)**
1.2 Date of description:	22/6/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Flemish Brabant, Diest Municipality. From Diest city take road N29 in north eastern direction for a few km. Change to road N174 (Nieuwe Dijkstraat) in northern direction. After 2 km follow the Engelbeekstraat (later changing into Kelbergenstraat) running eastwards. After about 1250 m turn into Peerstraat on the left side (towards North). Follow this road for about 850 m, turn right along a narrow road called Wijnstraat, which runs parallel with a football field, immediately before the house on the right side, turn right along the field track (or park the car here). This track goes through a tree nursery, specialised in cultivation of large trees (until 6-8 m high). After a few hundred meters along the field track, on the left side a forest appears (photo 13). The experimental plot is located in the upper half of this forest, which forms part of Kenisberg.
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 44 *Code profile:* 406 *Latitude, longitude:* 51° 01' 06.73" N; 5° 05' 46.55" E (centre forest plot)
1.6 Elevation:	35-37.5 m a.s.l.
2.1 Atmospheric climate and weather condition:	Sunny with warm temperatures of about 25°C. No rains in the days prior to the field work.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The region is characterised by several relatively steep hills that tend to form SW-NE oriented rows. The experimental plot is located on such a hill. To the south we find the river valley of the Zwarte Beek, to the north the river valley the Kleine and the Grote Beek is found. Both river valleys have an orientation parallel with the row of hills (SW-NE). The central parts of the hills are generally forested, due to the steep slopes, on the foot slopes we find agriculture. Kenisberg is with 43 m, a bit lower than most hills, which tend to reach altitudes of 50-55 m. The profile slope drains towards the Kleine Beek, which ultimately feeds the Demer river. Heath lands are found in the area but more towards the valleys (figure 15, 16 and 17). *Meso topography:* The experimental plot is located on a for Flanders relatively steep slope, probably too steep for modern day agriculture. Old ditches with a mutual distance of 25 m, could mark old field borders. *Landscape position:* the profile is located on the transition between the middle and the upper slope. Distance to the top of the slope (measured along the slope) is 23.7 m. Distance to an important convex change of the upper slope is 12.5 m. *Slope form:* VV (convex, convex) *Slope gradient:* 11.66° *Slope length:* about 350 m *Slope orientation:* dipping towards NNW (330°)
2.4 Land-use:	Plantation forestry with selective felling.

	Wildlife: Not known if protected. *Grazing:* No evidences of wildlife grazing, not fenced.
2.5 Human influence:	Vegetation slightly disturbed. A mountain bike track running through the forest cause some local impact on the ground vegetation (photo 14). The forest is planted.
2.6 Vegetation:	Coniferous forest.

Tree layer		**Shrub layer**		**Herb layer**	
Northern Red Oak	*Quercus rubra*	Snowy Mespilus	*Amelanchier lamarckii*	Common Bracken	*Pteridium aquilinum*
Scots Pine	*Pinus sylvestris*			Brambles	*Rubus sp.*
				European Honeysuckle	*Lonicera periclymenum*
				Mountain Ash	*Sorbus aucuparia*

2.7 Parent material:	Tertiary sand (5111)
2.8 Drainage class:	Well drained *Availability of water:* Sufficient
2.9 Internal drainage:	Never saturated
2.10 External drainage:	Moderately rapid run-off
2.12 Groundwater:	No water table observed
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	Moderate, active erosion along the mountain bike track, covering <2% of the surface.
2.17 Surface cracks:	None
Humus classification:	Locally presence of a very thin OHz, with an abrupt transition to the underlying Ajz horizon. No evidences of earthworms; Plenty of faunal activity in the OFz layer *Horizon sequence for humus classification:* OL, OFz, OHz discont., Ajz (photo 16). *Classification name:* The profile is located in a landscape position with presence and absence of a (very thin) OHz discont. horizon it will therefore key out as a Hemimoder. The humus type for P2 and P3 was not determined but are very similar to the one of P1 (see also photo 17 and 20)
Remarks:	Due to administrative problems only a small profile (Deurne 1) was made in June 2006. This profile was about 35 cm wide and 65 cm deep. Further observations were made with the help of a gauge auger (62-109 cm depth). After having solved the administrative problems a new and larger profile was studied in November 2006, referred to as Deurne 2. The profile description is based on Deurne 1, but with additional observations from Deurne 2. The profile has in general an excellent root growth as well vertically as horizontally. Many decaying roots observed as well as living roots. The living roots grow preferentially in the galleries of decaying roots.

No.		**Horizon description** (see also photo 15)
H1	OL	-3 till -2 cm; very thin (±2 mm), composed of oak leaves and pine needles
H2	OFz	-2-0 cm; upper part loose, lower part matted layer of *Quercus rubra* leaves; very dark greyish brown 10YR 3/2 (M); few faunal droppings; spiders observed; common fungi (mycelium); OM decay also by fungi.
pock ets	OHz	<1-0 cm; locally developed; very thin (2-3 mm); common very fine and fine roots, growing particular at contact between H1 and H2; abrupt broken boundary
H3	A/Ajz	0-3/5 cm; black to very dark brown 7.5YR 2.5/1.5 (M), very dark greyish brown 10YR 3/2 (D); loamy sand; common (5-15% by volume, 10% by weight), sub-angular and sub-rounded, weathered, fine to coarse (<3 cm) gravels of iron cemented sandstone mineralogy, some breakable by hands some by spade, coarse fragments present from upper limit of the mineral soil; weak, coarse (2-4 cm) sub-angular blocky; soft, very friable; medium porosity; few very fine to fine roots; clear smooth boundary

H4	Bw1	3/5-28 cm; brown 10YR 4/3 (W), brown to dark yellowish brown 10YR 4/3.5 (M), 10YR 4/3 (D); loamy sand; common (<15% by volume, 15% by weight), sub-angular and angular, weathered, fine to coarse gravels and stones (<10 cm) of iron cemented sandstone mineralogy; single grain; soft, very friable; high porosity; few, very fine to fine and very few medium to coarse roots; gradual wavy boundary
H5	Bw2	28-47 cm; brown 10YR 4/3 (W), brown to dark yellowish brown 10YR 4/3.5 (M), yellowish brown 10YR 5/5 (D); loamy sand; common (15-30% by volume, 8% by weight), sub-angular, weathered, iron cemented sandstone, fine to coarse gravels and stones (<7 cm); single grain; soft (D), loose (M); high porosity; few very fine to medium and very few coarse roots; gradual, wavy boundary;
H6	BC	47-80 cm; olive brown 2.5Y 4/4 (M), light olive brown 2.5Y 5/4 (D); sandy loam; very few (0-2% by volume, <1% by weight), sub-angular and flat, weathered, fine gravels of iron cemented sandstone mineralogy; massive, locally incomplete, weak, medium (1-3 cm), angular blocks; friable; medium porosity; few very fine to fine and very few medium to coarse roots; clear wavy boundary
H7	C1	80-100 cm; olive 5Y 4/3 (M), olive 5Y 5/3.5 (D), dark grey to olive grey 5Y 4/1.5 (MC); sandy clay loam; very few (<1% by weight), sub-angular, weathered, fine gravels of iron cemented sandstone mineralogy; single grain; loose; medium porosity; very few very fine to fine roots; abrupt smooth boundary
H8	C2	100-…. cm; no stones; massive; slightly hard; medium porosity; very few very fine to fine roots

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Photo 13: View on forest plot 406 (Photo JM)

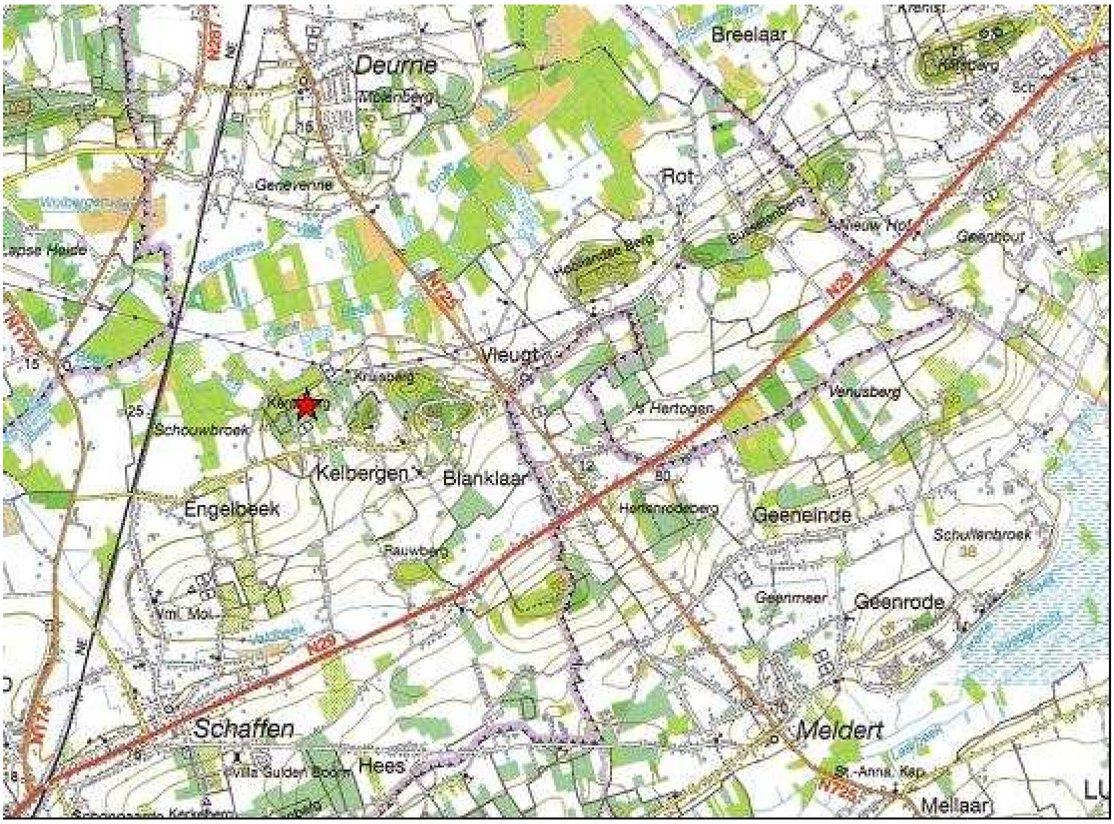

Figure 16: Topographical map of the region surrounding profile 406. The distance from west to east is 7550 m (NGI, 2002, map 83).


Figure 17: Orthophotographic view if the forest plot hosting plot 406. The distance from west to east is 1775 m (Eurosence, 1987).

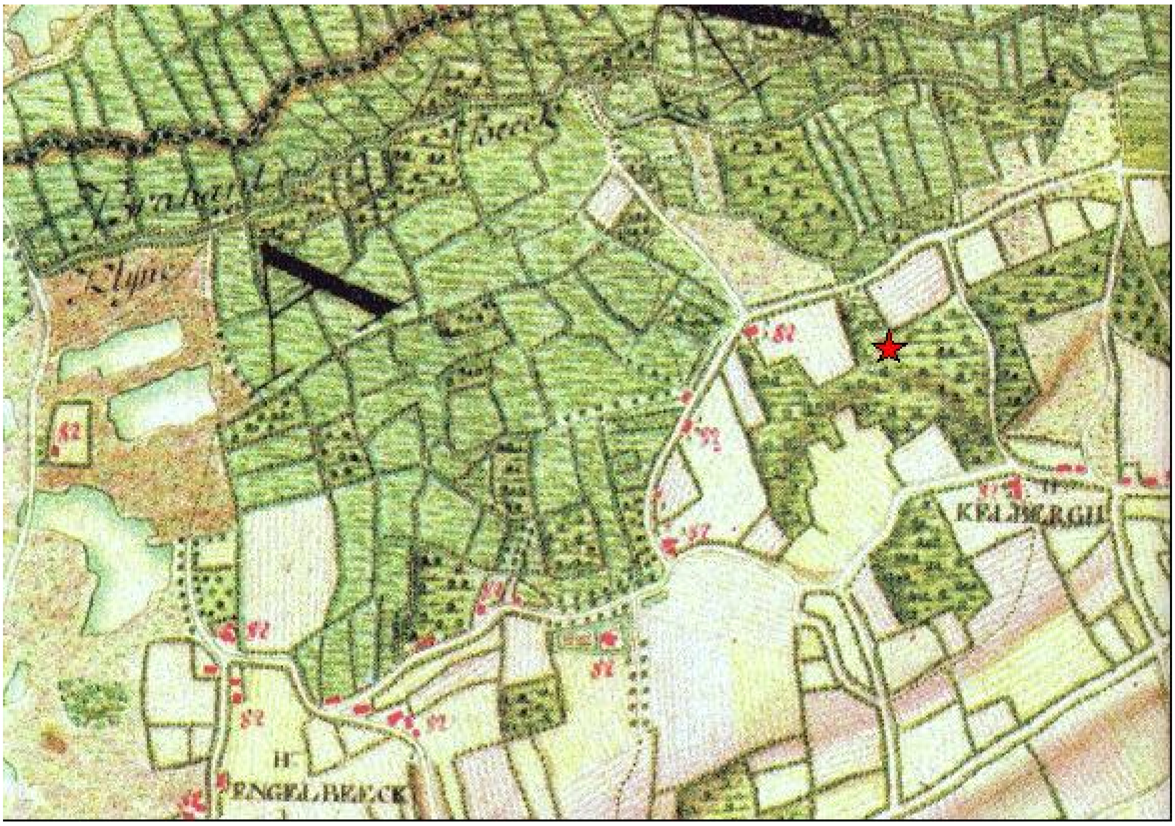

Figure 18: Cut out of the Ferraris map of Engsbergen (Ferraris, 1777, map nr. 130/2). The distance from west to east is 2420 m.

Photo 14: View on the forested north facing slope of the Kenisberg, hosting the Level I plot nr. 406. Through the forest runs a bike and hiking trail. Profiles 1-3 are all located above this trail (Photo JM0029).

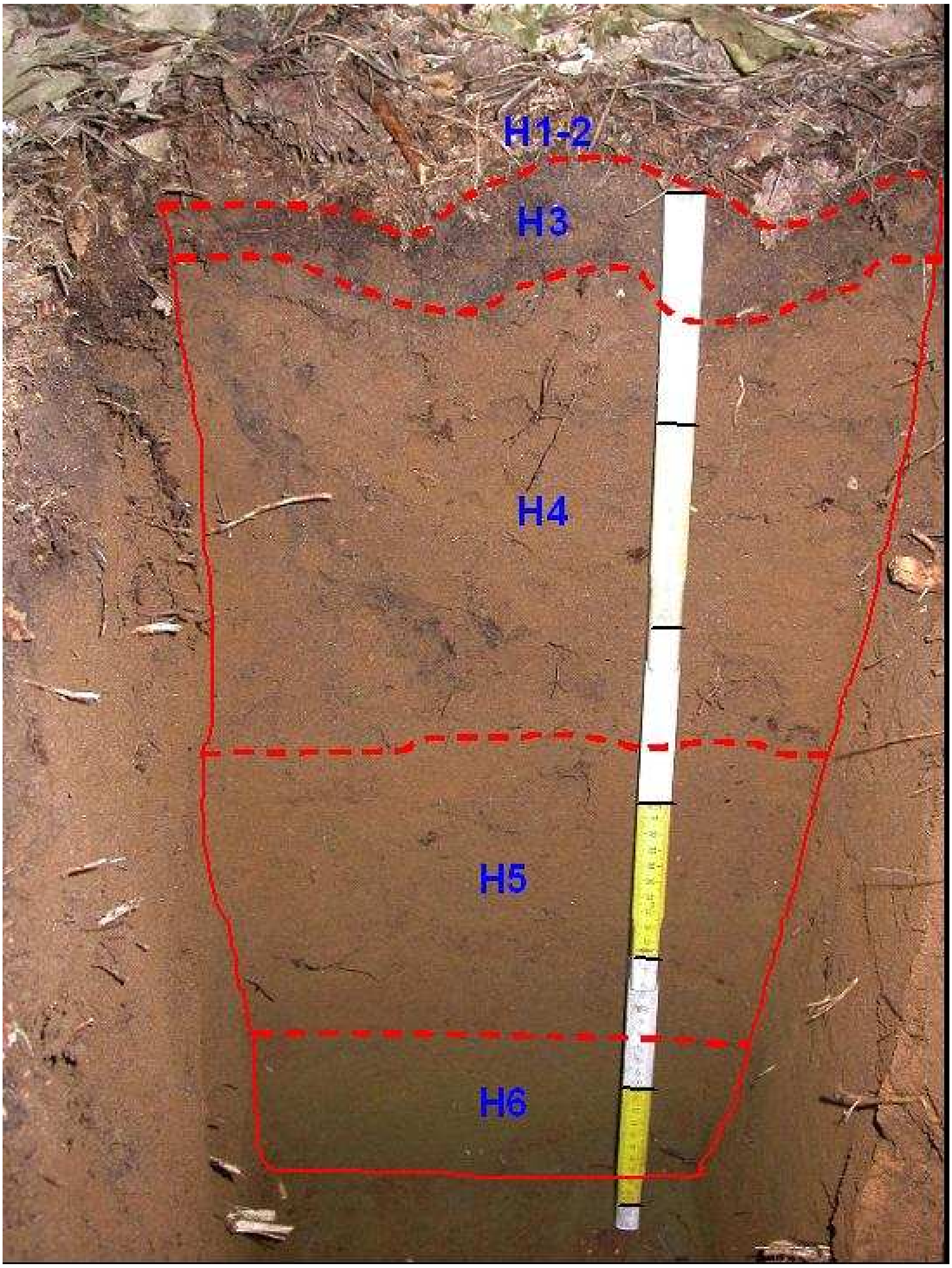

Photo 15: View on profile 406 (Deurne 1) (Photo by JM, DSCN 9414)

Photo 16: Cut through the litter layers and the upper mineral soil horizons. The forest floor was classified as a Hemimoder.

6.2. Analytical data

Table 13: Analytical data for profile 406-P1, Deurne, Flemish Brabant, Belgium. Profile studied 22/6/2006. Profile analysed: 09/2006 - 02/2007.

Horizon	Horizon	Depth	Total N (Kjeldahl)		Org. Carbon		OM	pH			Coarse frag.
nr.	symbols		Modified	Standard	TOC	W&B	LOI	H_2O	H_2O	$CaCl_2$	>2mm
		cm	%	%	%	%	%	1:1	1:5	1:5	%-wght
1	OL	3-2									
2	OF	2-0	1.248				62		4.1	3.3	
3	A	0-3/5	0.369		8.73	4.2	5		3.8	3.1	9.7
4	Bw1	3/5-28	0.059		0.84	0.7			4.3	3.5	15.4
5	Bw2	28-47	0.034		0.46	0.5			4.2	3.6	8.3
6	BC	47-80			0.23	0.2			4.0	3.4	0.2
7	C	80-…				0.3			4.0	3.4	0.0

Horizon	Particle size distribution (fractions in µm)										
nr.	0-2	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
	---%---										
1											
2											
3	5.5	2.2	0.7	4.1	0.2	2.4	3.5	42.9	28.7	8.8	1.0
4	7.0	3.2	0.8	4.7	0.2	2.3	3.0	40.6	26.8	7.4	3.7
5	6.9	2.9	1.3	4.0	0.3	2.5	3.3	48.3	25.6	4.1	0.8
6	12.8	4.0	1.4	3.9	0.2	1.1	1.6	35.8	35.6	3.5	0.1
7	23.5	4.5	1.9	6.7	0.2	1.5	2.4	35.6	19.8	3.7	0.2

Horizon	Mg^{++}	Na^+	K^+	Ca^{++}	CEC	BS	CEC/	Al	Fe	Al	Fe
nr.	--------by NH_4OAc--------						clay	Dithi. Citrate		Oxalate	
	--------cmol(+)/kg soil'--------					%		%		%	
1											
2	0.64	0.24	0.99	11.40	46.0	29			0.734	0.051	0.243
3	0.60	0.11	0.57	2.24	22.3	16			0.829	0.061	0.253
4	0.19	0.04	0.21	0.11	5.5	10	37		1.180	0.061	0.228
5	0.19	0.03	0.17	0.06	4.1	11	36		1.066	0.071	0.254
6	0.21	0.03	0.21	0.05	6.5	8	44		0.887	0.102	0.223
7										0.123	0.335

Table 12 (continued): Analytical data for profile 406-P1, Deurne, Flemish Brabant, Belgium

Horizon nr.	Horizon symbols	Depth	Mg++	Na+	K+	Ca++	Al+++	Fe+++	Mn++	Free H+	Lab nr.
			by $MgSO_4$ (compulsive method)								
		cm	cmol(+)/kg soil								
1	OL	3-2									JM97
2	OF	2-0	0.79	0.11	0.86	13.31	0.96	0.23	1.141	3.84	JM98
3	A	0-3/5	<0.25	0.05	0.59	2.42	2.23	0.20	0.125	1.92	JM99
4	Bw1	3/5-28	<0.12	<0.02	0.21	0.08	2.63	0.05	0.014	0.34	JM100
5	Bw2	28-47	<0.12	<0.02	0.17	0.03	2.77	<0.01	0.007	0.41	JM101
6	BC	47-80	<0.12	<0.02	0.22	0.03	4.57	<0.01	0.008	0.22	JM102
7	C	80-…	0.23	<0.03	0.29	0.63	5.82	<0.01	0.057	0.27	JM103

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
						Aqua Regia					
	cmol(+)/kg		%	cmol(+)/kg		mg/kg					
1						1637	7777	662	136	920	1722
2	21.2	<18	>100	6.2	5.3	2993	2841	915	82	702	1437
3	7.5	8.6	37	4.5	4.9	5757	710	2195	53	503	609
4	3.3	3.8	10	3.0	3.4	6859	106	2647	30	255	130
5	3.4	3.7	7	3.2	3.3	2743	718	1645	44	192	95
6	5.0	6.1	5	4.8	5.4	14204	114	5099	25	152	76
7	7.3	9.5	12	6.1	6.9	18617	197	7173	39	197	109

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	Aqua Regia									dS/m	
	mg/kg									1:5	%
1	1037	1.40	15.2	2581	1231	5	21.9	4.3	269		
2	3409	0.88	13.7	42110	409	22	49.1	5.5	216	0.12	
3	6515	1.04	15.0	46858	112	34	69.5	7.1	122	0.09	
4	6878	0.66	2.5	51047	64	35	12.3	3.6	61	0.10	
5	7078	0.62	2.3	44753	42	37	6.7	4.2	70	0.02	
6	12196	0.80	1.2	58137	24	55	5.0	6.4	84	0.03	
7	17267	1.19	1.1	80182	43	77	6.4	9.0	61	0.04	

Table 14: Bulk density and water holding capacity for profile 406-P1, Deurne

Horizon nr.	Horizon symbols	Depth	Actual water cont.	BD_S soil	BD_{FE} fine earth	Lab nr.
		cm	%	g/cm3	g/cm3	
1	OL	3-2	23			JM97
2	OF	2-0	36			JM98
3	A	0-3/5	25			JM99
4	Bw1	4	2	1.31	1.30	JM100
4	Bw1	15		1.43	1.38	
5	Bw2	28-47	6	1.48	1.48	JM101
6	BC	47-80	8	1.53	1.53	JM102
7	C	80-…	11			JM103

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	Vol. % water							
1								
2								
3								
4	52.3	46.8	31.9	22.6	13.9	11.4	8.6	5.7
4	49.8	47.5	32.2	21.9	11.7	8.7	9.6	6.4
5	52.0	51.5	33.0	22.4	14.8	12.0	11.3	7.8
6	53.9	46.6	30.9	12.8	10.6	9.9	9.4	6.2
7								

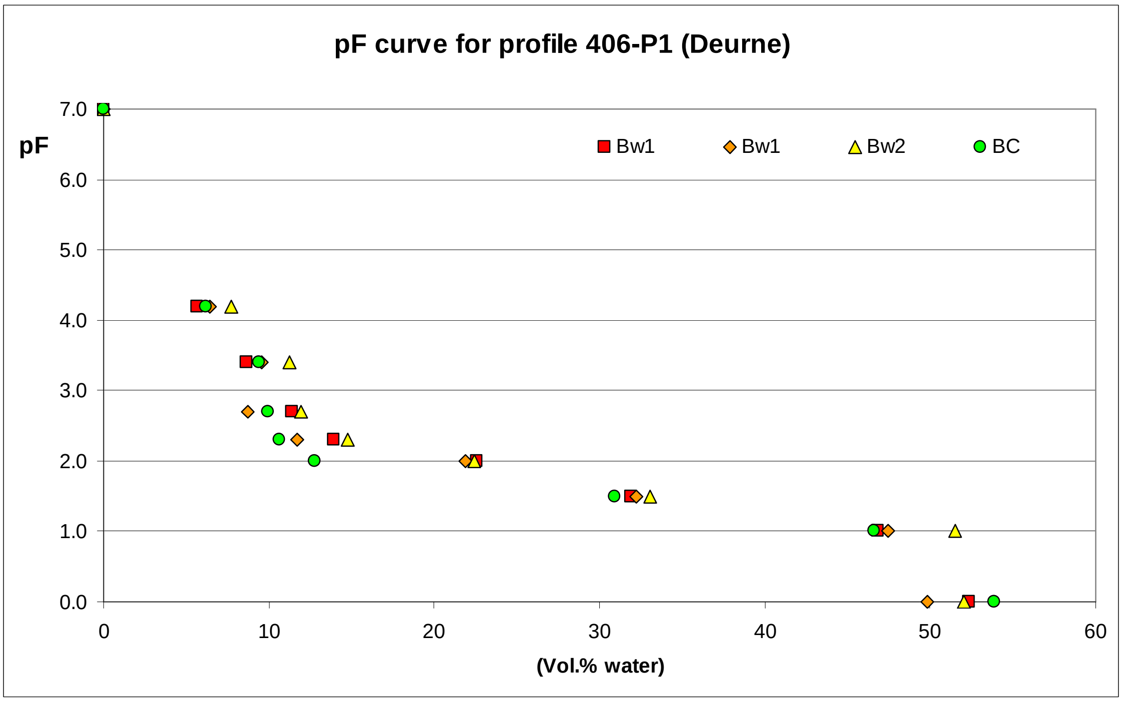

Figure 19: The pF curve for profile 406-P1, Deurne

The laboratory data are discussed in paragraph 8.4.

6.3. Information deduced from the Belgian Soil Map

Forest Plot 406 is located on soil map 61W (Scheys, Baeyens and Tavernier, 1960). Within this map the substratum is Diestiaan of Pliocene age. This is glauconite rich (clayey) sand that has been weathered into red-brown stony sands containing limonite on the higher landscape positions. On slopes and eroded places the substratum appears as sandy heavy weathering clays (Baeyens and Tavernier, 1960).

On the soil map, 4 different soil regions are recognised (figure 19). These are:

1) The drift sand dunes, with excessive drainage and sparse vegetation, part are planted with conifers.
2) A mixed area of drift sand and tertiary hills characterising the southern and central part of the soil map. A gently rolling landscape with soils that are moderately to poorly drained. Forests are located on the tertiary hills and on the driest soils.
3) Light sand loam landscape in the northern part of the map, with wet to very wet silty soils with strong reliefs. Grasslands and deciduous forests are widespread here.
4) The river valleys, composed of clayey and silty sediments with high groundwater tables. Pastures and deciduous forests are dominating this landscape unit.

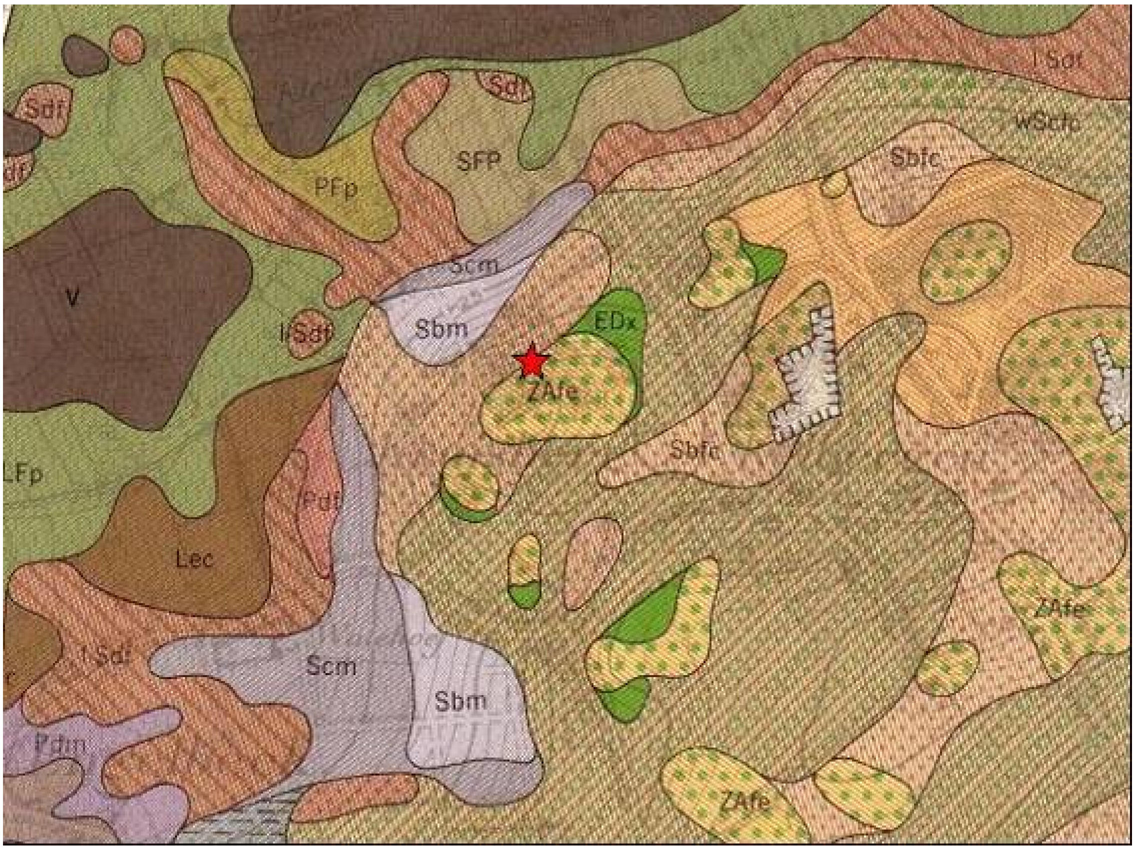

Figure 20: Detail of soil map 61W, with soil profile 406 (Deurne 1) indicated. The distance from west to east is 1880 m (Scheys, Baeyens and Tavernier, 1960).

Deurne 1, the first profile investigated at this plot and presented first lies within map unit Sbfc. Deurne 2 is a second mid slope profile but with a very different horizon sequence. It belongs to map symbol ZAfe. A third soil profile located as well on the mid slope but additional 30-40 m to the west showed yet a different horizon sequence. On the foot slope soils with map unit Sbm have developed (Table 14).

Table 15: Concise description of the soil map units in the immediate vicinity of the Deurne soil profile (Plot nr. 406).

Map symbol	Description
ZAfe	Very dry till moderate wet sandy soils with weakly developed humus and/or iron B horizon. Variant with deep B-horizon on yellowish or greenish stony sands.
Sbfc	Dry silty-sand soils with weakly developed humus and/or iron B horizon. Variant with deep iron B-horizon on yellowish or greenish stony silty sand.
EDx	Weak to moderate gleyic heavy clay soils with no clear profile development
Sbm	Dry silty sand soils with deep anthropogenic humus A horizon.
Scm	Moderate dry silty sand soils with deep anthropogenic humus A horizon.
wZbfc	The first studied soil profile (Deurne 1), and also the one to be reported to the central database.

The Sbfc soils are brown Podzol like soils with an iron B-horizon. They have a roughly 40 cm thick red-brown B-horizon. The C horizon is greenish and contains high amounts of glauconite. The substratum is composed of sandy weathering clay. In the summer these soils are mostly dry. Deurne 1, the soil profile presented here, is enclosed within this map unit. The soil type is abbreviated as wZbfc, as the soil has clayey subsoil within shallow depth, and the texture is sandy in the upper horizons.

The ZAfe soils are brown Podzol like soils developed on Sandy Diestiaan, composed of glauconite rich sands with limonite (iron sandstone) concretions from palaeosoils. The soils may have traces of a very thin E horizon. They are excessively drained in the upper part, but with a poor internal drainage due to the presence of clay and glauconite. This stony soil type is mostly forested or left as heath lands. Due to the presence of stones they are not used for agriculture.

6.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material:	Present in horizon	Remarks
Albic	-	
Cambic	-	Texture is loamy sand
Spodic	-	In absence of an Albic horizon the colours are too yellowish

Simplified classification name
H6-7 have too fine textures for Arenosols, as the soil should have sand or loamy sand texture from the soil surface to a depth of 100 cm. Furthermore H3-5 have too coarse textures for Cambic horizon. This results in a profile that will key out in Regosols. **Haplic Regosol**

Full classification name without specifiers
Haplic Regosol (Dystric, Arenic) • The information on a coloured B-horizon (Brunic) is not listed for Regosols

BioSoil classification name (WRB 2006), with specifiers
Haplic Regosol (Hyperdystric, Arenic)

7. Profile 406-P2, Deurne, Flemish Brabant

7.1. Site and profile description

Profile 406-P2 is located about 10 m to the west from profile 406-P1 but at the same slope position. It was studied 5 months after profile 406-P1. Where P1 was a mini profile supported with auger observations, P2 is a full size profile (photo 18). No separate profile description was made, but the horizons were sampled and analysed in the laboratory, the data available are presented in following tables.

Photo 17: The humus type for profile 406-P2 is similar to 406-P2 (Photo JM)

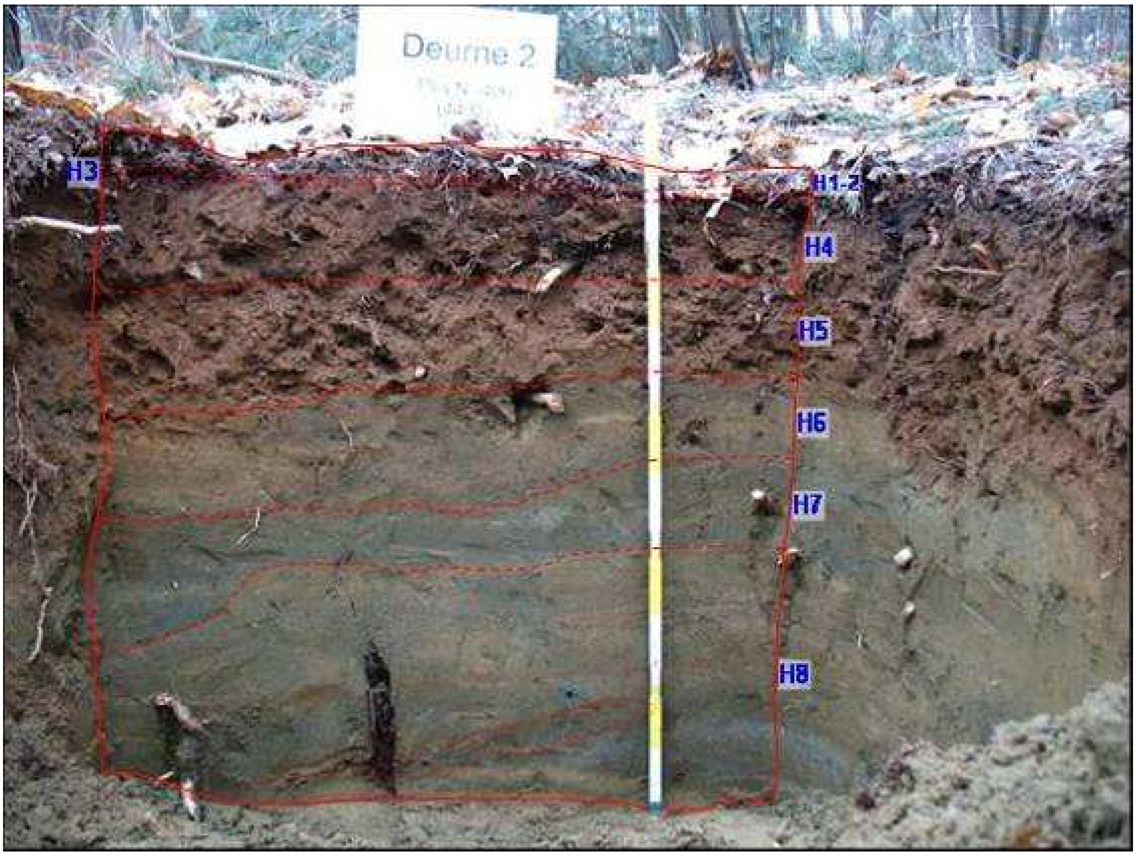

Photo 18: View on profile Deurne 2 (Located at about 10 m distance from Deurne 1, and at the same slope position) (Photo JM)

7.2. Analytical data

Table 16: Analytical data for profile 406-P2, Deurne, Flemish Brabant, Belgium. The profile was studied in the field on 17/11/2006, and analysed in the laboratory in the period 12/2006 - 03/2007.

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Total N (Kjeldahl) Standard %	Org. Carbon TOC %	Org. Carbon W&B %	OM LOI %	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm %-wght
1	OL	5-4	0.926	0.995	54.33				4.8	4.4	
2	OF	4-0	1.325	1.388	46.11				4.7	4.1	
3	A	0-2	0.439	0.447	8.98	6.7		3.7	3.9	3.2	49
4	Bw1	2-11	0.050	0.050	1.03	0.8		3.8	3.8	3.3	35
5	Bw2	11-26/30	0.027	0.024	0.30	0.3		4.0	4.0	3.6	20
6	Bt1	26/30-37/49	0.020	0.019	0.21	<0.1		4.0	4.0	3.4	42
7	C	37/49-49/57	0.022	0.016	0.16	<0.1		4.0	4.0	3.4	
8	Bt2	49/57-	0.019	0.019	0.15	<0.1		4.0	3.9	3.3	

Horizon nr.	Particle size distribution (fractions in µm) 0-2 %	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
1											
2											
3	8.7	4.5	2.5	7.0	0.3	2.9	3.6	38.9	21.7	8.3	1.5
4	5.7	3.4	2.2	6.8	0.2	3.1	4.4	45.0	21.6	6.4	1.2
5	5.0	3.2	1.2	6.3	0.5	1.9	3.2	43.5	22.2	10.2	2.9
6	18.5	1.5	3.0	6.4	0.0	1.6	3.5	42.5	18.0	4.3	0.7
7	8.4	3.0	1.5	6.7	0.3	1.4	3.1	44.3	24.8	6.2	0.4
8	18.7	1.9	2.8	6.8	0.3	1.2	2.1	33.7	27.4	4.9	0.3

Horizon nr.	Mg++ (by NH_4OAc, cmol(+)/kg soil)	Na+	K+	Ca++	CEC	BS %	CEC/clay	Al Dithi. Citrate %	Fe Dithi. Citrate %	Al Oxalate %	Fe Oxalate %
1	7.42	0.98	6.40	19.78	37.3	93				0.021	0.046
2	4.36	0.37	2.56	22.48	56.9	52				0.044	0.113
3	0.53	<0.22	0.52	2.73	26.2	<15				0.092	0.291
4	<0.28	<0.22	0.15	<0.5	5.9	<11	42			0.052	0.251
5	<0.28	<0.22	<0.13	<0.5	5.1	<11	81			0.071	0.294
6	<0.28	<0.22	0.25	<0.5	8.3	<9	41			0.105	0.238
7	<0.28	<0.22	0.20	<0.5	7.8	<9	86			0.097	0.114
8	<0.28	<0.22	0.28	<0.5	10.3	<8	52			0.105	0.203

Horizon nr.	Horizon symbols	Depth cm	Mg++ (by $MgSO_4$ (compulsive method), cmol(+)/kg soil)	Na+	K+	Ca++	Al+++	Fe+++	Mn++	Free H+	Lab nr.
1	OL	5-4	3.85	1.26	4.00	9.35	<0.18	0.07	5.391	5.36	JM182
2	OF	4-0	2.04	0.43	2.94	13.13	0.29	0.04	3.037	3.18	JM183
3	A	0-2	<0.56	<0.09	0.52	1.62	3.43	0.33	0.137	3.42	JM184
4	Bw1	2-11	<0.12	<0.02	0.18	0.14	2.39	0.06	0.019	0.50	JM185
5	Bw2	11-26/30	<0.12	<0.02	0.10	0.02	2.63	0.01	0.007	0.27	JM186
6	Bt1	26/30-37/49	<0.12	0.02	0.22	0.04	4.81	0.01	0.007	0.66	JM187
7	C	37/49-49/57	<0.12	<0.02	0.21	0.04	4.63	0.01	0.006	0.31	JM188
8	Bt2	49/57-	0.17	0.03	0.24	0.23	4.91	0.02	0.034	0.51	JM189

Horizon nr.	CEC sum cmol(+)/kg	CEC measured cmol(+)/kg	BS by CEC-m %	Acidity sum cmol(+)/kg	Acidity titrated cmol(+)/kg	K (Aqua Regia, mg/kg)	Ca	Mg	Na	P	S
1	29.3	25.6	72	10.8	8.8	3633	10109	1391	400	571	1014
2	25.1	33.6	55	6.5	6.4	2395	7584	1122	159	785	1813
3	9.5	14.0	<18	7.3	10.1	4601	796	1937	80	464	821
4	3.3	4.2	<9	3.0	3.8	5511	167	2174	55	217	268
5	3.0	4.0	<5	2.9	3.8	6190	139	2399	46	189	261
6	5.8	6.8	<5	5.5	7.1	14613	94	5178	70	100	98
7	5.2	6.3	<5	5.0	6.4	15204	77	5025	55	75	57
8	6.1	7.9	<9	5.5	7.1	19077	184	6338	65	112	76

Horizon nr.	Al (Aqua Regia, mg/kg)	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC dS/m 1:5	$CaCO_3$ %
1	785	0.76	7.0	3581	1937	4	7.8	2.5	174	0.25	
2	1938	1.41	16.2	20344	1546	12	34.0	5.5	278	0.28	
3	7396	0.59	24.1	62075	109	38	132.1	9.1	192	0.11	
4	7006	0.21	2.5	77466	67	40	15.3	4.6	68	0.05	
5	8262	0.18	1.4	84697	49	44	9.8	7.0	74	0.04	
6	14863	0.14	1.2	65282	29	60	5.8	8.4	106	0.04	
7	14348	0.15	0.8	58400	18	59	5.0	7.8	96	0.03	
8	17692	0.26	0.9	79523	41	72	6.5	10.4	128	0.06	

The analytical results are discussed in paragraph 8.4.

7.3. Classification according to World Reference Base (2006)

This is a difficult soil to classify. Firstly, no separate profile description was made, so we have to rely on the one made for P1 and the photos. Secondly, the soil as it appears today must have undergone severe erosion with removal of most of the fine earth fraction from the original soil profile. It is not clear whether this erosion took place over a short period of severe erosion, e.g. after a period of clear cut, or over years in function e.g. of a period of agricultural activity. The result of the soil erosion is obvious. What remains today is a soil with a 5 cm litter layer overlying a 28 cm thick soil with a high content of gravels, mostly iron concretions and cementations, coarse fragments that were too large to be transported downslope. Deeper in the soil are tertiary sediments where ancient clay migration bands are found. The colour difference between the upper weathered reddish soil and the lower greenish sediment is striking.
In order to classify this soil, it is very important to know whether H6 and H8 are Argic horizons or not. If they are the soil will key out in Alisols. Observing the morphology of the soil and the rather shallow pedon a more correct classification name would be Regosol. Nevertheless the classification key should be followed and the result should be respected.

Diagnostic horizon, properties, material	Present in horizon	Remarks
Argic	H8	Both the clay increase and the thickness are fulfilled for H6 and H8, but just above H6 is a lithological discontinuity; which implies that the illuvial nature of this horizon must be clearly established, which is not the case as no clay coatings were observed!
Cambic	H6	Only H3, H6 and H8 have a texture fine enough for Cambic. H3 is a mineral surface horizon, which is against the concept of Cambic. H8 is qualifying for Argic, which can not coincide with Cambic. H6 has a higher chroma than the underlying horizon.
Spodic	-	No Albic horizon present and oxalate extractable Aluminium is far below the required 0.5%.
Abrupt textural change	Between H5-6 Between H7-8	
Lithological discontinuity	Between H5-6	The colour contrast and the increase in clay content from 5.0-18.5% are evidences of a lithological discontinuity. A lithological discontinuity is not present between H7 and H8, as both horizons belongs to the same tertiary material, and the clay increase from 8.4 to 18.7% can be explained by clay migration.

Simplified classification name

Haplic Alisol

- Hyperalic: The silt to clay ratio for H8 is 0.63, which is a bit too high as it should be less than 0.6 to qualify. H6 has a ratio of 0.58 but as the illuvial nature of this horizon can not be established, it is not an Argic horizon.
- Cutanic: Clay coatings were not observed
- H6 has the colour 5Y 5/3 (dry), which is one chroma unit too high to qualify for Albic

Full classification name without specifiers

Haplic Alisol (Abruptic, Ruptic, Alumic, Hyperdystric)

- Skeletic: the content of gravel is ranging from 20-49% measured by weight. By volume the percentage will become smaller due to the higher bulk density of stones compared to soil. So a criteria of 40% by volume coarse particles on average to a depth of 100 cm will not be fulfilled.

- Arenic: H4-5 have a loamy sand texture but the thickness is less than the required 30 cm.

BioSoil classification name (WRB 2006), with specifiers
Haplic Alisol (Epiabruptic, Epiruptic, Hyperalumic, Hyperdystric)   • By definition Alisols are Endodystric, that is why only Hyperdystric is listed among the qualifiers.

8. Profile 406-P3, Deurne, Flemish Brabant

8.1. Site and profile description

As part of the BioSoil Workshop on 'World Reference Base 2006', FSCC organised a field excursion in March 2007. One of the excursion points was Deurne. For this occasion P1 and P2 should have been reopened but due to a mistake instead of P1 a new profile was opened. The slope position is the same as for the previous profiles, though it is located additional 30-40 m to the west of the previous profiles.

406-P3 is a very interesting profile because of two things. Firstly it is highly eroded, so that most of the soil pedon has been washed downslope, leaving a soil with a thin pedon resting on an ancient soil with Bt bands developed in the tertiary material (photo 19). Secondly, in top of the soil an old plough layer was observed, a horizon that was absent in the previous two profiles. After a careful study of the surface morphology indeed a slight height difference running parallel with the slope was observed between P1 and P2. This indicates a field limit. Evidently the field to the east hosting profile 2 has never been ploughed or at least insufficiently to leave any traces in the soil. P3 located on the field to the west, has on the other hand been ploughed several times, sufficiently to develop a visible plough layer. P1 is located to the west of the field limit, but shows no traces of a plough layer, possible due to erosion or possibly because this profile was a miniprofile and detecting very week visible Ap layers demands a larger exposed profile surface to be spotted. Probably the severe erosion that P3 has undergone is related to a phase of cultivation. Later the two fields were merged together in one, which was planted with conifers.

Photo 19:Close up on the thin forest floor characterising profile 406-P3 (Photo JM)

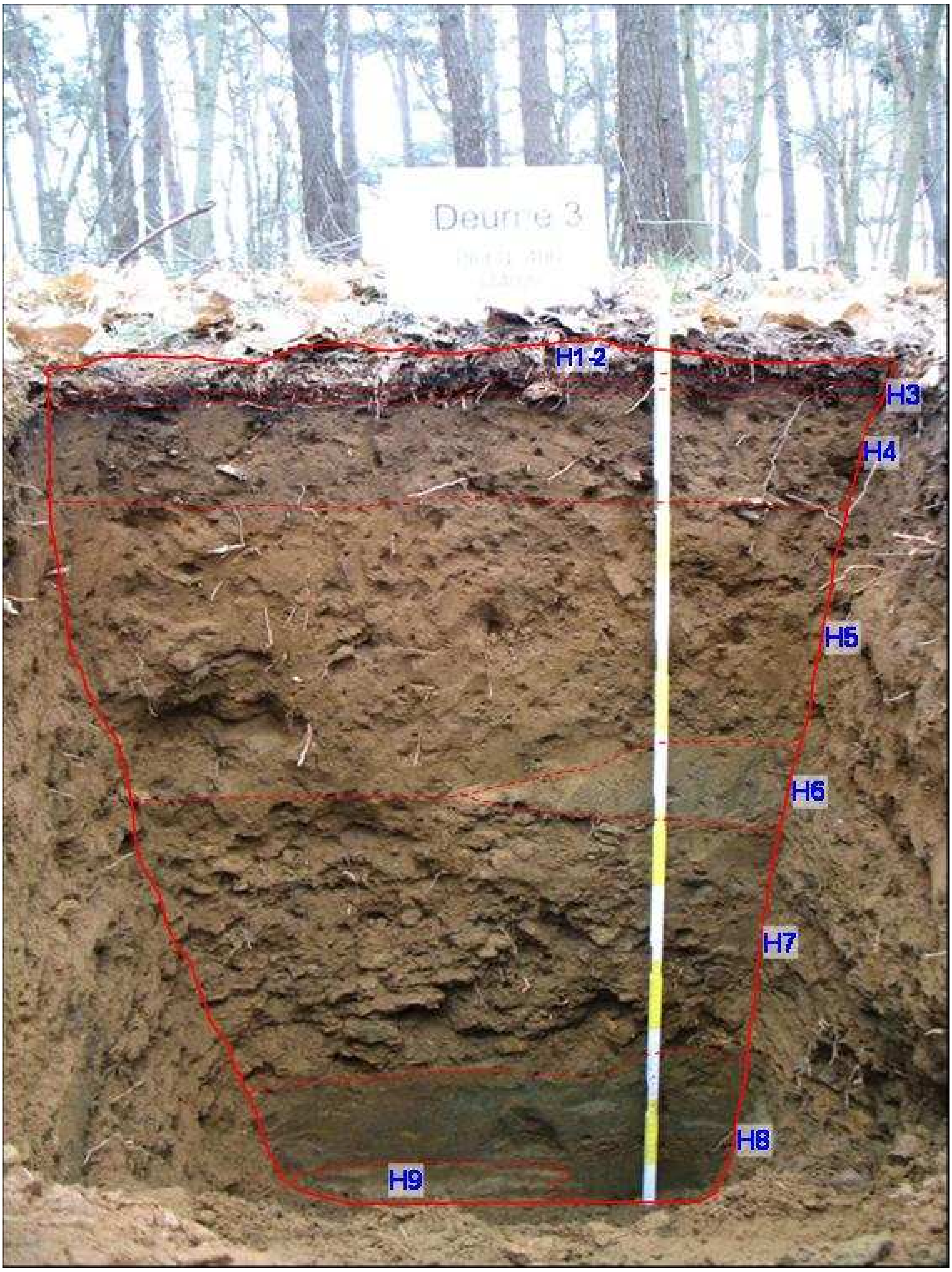

Photo 20: Soil profile Deurne 3 as it appeared after fieldwork

8.2. Analytical data

Table 17: Analytical data for profile 406-P3, Deurne, Flemish Brabant, Belgium. Profile studied 9/3/2007. Profile analysed 09/2007 - 04/2008.

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Total N (Kjeldahl) Standard %	Org. Carbon TOC %	Org. Carbon W&B %	OM LOI %	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Lab nr.
1	OL	4-3									JM190
2	OF	3-0									JM191
3	Ah	0-2	0.141	0.246	21.04		26.0		4.1	3.3	JM192
4	Ap	2-16	0.040	0.043	0.73		2.6		4.2	3.5	JM193
5	Bwbi	16-44/50	0.021	0.022	0.19		1.6		4.6	4.0	JM194
6	pocket	44-56	0.047	0.026	0.23				4.2	3.6	JM195
7	BCbi	50/56-88	0.036		0.25		2.6		4.4	3.8	JM196
8	C1	88-104/110	0.037		0.11		1.9		4.5	3.7	JM197
9	C2	104/110-...	0.036		0.14		2.0		4.6	3.8	JM198

Horizon nr.	Particle size distribution (fractions in µm) 0-2	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
	%										
1											
2											
3											
4	6.7	2.3	1.0	4.5	0.6	2.3	2.7	31.9	23.7	5.7	18.6
5	4.9	2.7	0.9	3.6	0.6	2.2	2.8	41.5	32.0	6.0	2.7
6											
7	12.6	3.1	1.5	5.1	0.4	1.3	1.9	31.6	25.1	7.5	9.8
8	23.2	3.2	1.7	5.8	0.2	0.8	1.3	23.4	30.7	9.7	0.0
9	20.9	3.7	1.0	5.9	0.3	1.5	3.2	48.9	11.9	2.6	0.1

Horizon nr.	K	Ca	Mg	Na	P	S	EC dS/m 1:5	Al Dithi. Citrate %	Fe Dithi. Citrate %	Al Oxalate %	Fe Oxalate %
	Aqua Regia mg/kg										
1											
2											
3		1186			757	1278	0.14			0.120	0.240
4		212			342	168	0.04			0.055	0.173
5		138			249	140	0.02			0.060	0.080
6		320			250	173	0.05			0.084	0.132
7		489			310	227	0.04			0.064	0.089
8							0.04				
9							0.04				

8.3. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material	Present in horizon	Remarks
Argic	H7	This horizon appeared by no means as an Argic horizon in the field, but due to the clay increase and the absence of a lithological discontinuity H7 can be considered as an Argic horizon.
Cambic	-	Too coarse texture
Abrupt textural change	Between H5-7	
Lithological discontinuity	-	Although between H5 and H7 an abrupt textural change is present, this is not a lithological discontinuity, as the lithology (parent material) and the pedological evolution seems to be very similar.
Colluvic	-	No, this is a soil that has experienced colluvial erosion not sedimentation

Simplified classification name
No data on the CEC of the profile are available. Using data from profile 406-P1 and 406-P2 located very close by, it can be assumed that this profile as well will have a CEC by clay above 24 cmol(+)/kg clay and that the base saturation will not exceed 50%. The profile will due to the presence of an Argic horizon key out in Alisols. If the soil had no Argic horizon it would have keyed out in Regosols. **Haplic Alisol**

- The silt to clay ratio for H7 is 0.8 so too high for Hyperalic

Full classification name without specifiers
Haplic Alisol (Abruptic, Alumic, Hyperdystric, Profondic, Arenic) • Alumic, based on data from profile 406-P1 and 406-P2 • Hyperdystric, based on data from profile 406-P1 and 406-P2 • Profondic, no data below 130 cm depth, but most probably the clay content will not drop below the content of the Argic horizon • H4-5 both have loamy sand, qualifying for Arenic

BioSoil classification name (WRB 2006), with specifiers
Haplic Alisol (Endoabruptic, Alumic, Hyperdystric, Profondic, Epiarenic) • The abrupt textural change required for the Abruptic qualifier is found at a depth of 50 – 56 cm. Including the forest floor in to the depth measurement the border is clearly lower than 50 cm. For the endo-specifier, the qualifier should refer to a soil property starting between 50 and 100 cm from the soil surface including the litter layer. • Alumic, Hyperdystric and Profondic are based on assumptions, so no specifiers are applied

8.4. The laboratory data

The C/N ratio shows the same trend for all 3 profiles on plot 406 (Table 12, 15 and 16). A very high C/N ratio is characterising the litter layer and the A horizon. In the subsoil the ratio drops to 14 (profile 406-P1) or even below 12 (406-P2 and P3). Very high concentrations of organic carbon were measured in the A horizon. Actually in 406-P3 the content of organic carbon is 21% which implies that this horizon for classification purposes is considered an organic horizon. The horizon is only 2 cm thick. It is not excluded that another soil surveyor would have characterised this horizons as being a OH horizon. Below the A horizon the content of organic carbon is very low for all 3 profiles.

The content of coarse fragments is concentrated in the weathered B horizons of both P1 and P2, no data are available for P3. The coarse fraction is composed entirely of fine earth material cemented by iron. Characteristic for the 3 profiles is the increase in clay content with depth. P2 have 5-7% in the upper horizons and with 12.8 in H6 and 23.5% in H7. In P2 the upper horizons contain 5-9% with peaks in of around 18% in H6 and H8, both these horizons were described in the field as Bt horizons. In P3 the clay makes up 5-7% in the upper horizon and increases to 13-23% in the subsoil. It counts for all 3 profiles that the highest concentrations are found in the fraction 125-250µm and in the fraction 250-500 µm. In the Ap horizon of P3 the content of very coarse sand is 18.6%. Possibly these are the residues of a period of erosion where the finer material has been deposited downslope.

The content of basic cations below the forest floor is very low. In horizons without a considerable enrichment by organic material the CEC of the soil is also very low. The base saturation for P1 drops from 29% in the OF layer to 8% in the BC horizon. The same trend is found for P2. No data are available for P3. The aluminium saturation is high. Below the organic layers the saturation mostly exceeds 80% (Table 12, 15 and 16).

Dithionite and oxalate extractable iron are peaking in H4-5, with above 1% dithionite and about 0.25% oxalate extractable iron. In P2 no subsoil peak has been detected.

Throughout both P1 and P2 the content of iron extracted by aqua regia is high with values up to 8.5%. The parent material is composed of tertiary sediments with a high content of glauconite. As an important part of this mineral is iron, weathering will release high amounts of iron.

The bulk density is increasing with depth from 1.3 to 1.5 (g/cm^3) (Table 13). The water holding capacity is rather low. With only about 20% at field capacity and 5-8% at wilting point the soil contains about 15% plant available water (Table 13 and Figure 19).

8.5. Discussion

With three soil profiles instead of one much more information is available but it also reveals the complexity of the soilscape on the Kenisberg. The hill hosting the experimental site originates in tertiary sea sediments. Erosion on the hill slopes is obvious. The 3 profiles illustrate short distance variation in function of different land use history with one profile being strongly eroded probably linked to a phase of agricultural activity and two profiles carrying no clear traces of former agricultural activity and with the soil pedon being better preserved.
Two of the three soils are classified as Alisols. This is due to erosion which has brought Bt horizons close to the surface. Considering the relative shallow pedon with little pedogenesis it would have been more logical that all profiles would have keyed out in the major reference group of the Regosols.

In 1993, the soils of this plot were classified as 'Haplic Arenosol' according to FAO (1988). The particle size analyses of this survey showed however that this soil was and is not sandy enough (see H6 and H7 in profile 406-P1) to qualify for Arenosols. In 1993 no textural analyses were performed in function of the soil classification. However, in the 2006 survey this additional information was available, allowing us to classify this soil more accurately.

9. Profile 505, Schilde, Antwerp

9.1. Site and profile description

Profile 505	**Schilde (Level 1 forest plot)**
1.2 Date of description:	24/7/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Antwerp, Schilde Municipality (photo 21). From Sint Job–in-'t-Goor, follow the road Bethanienlei in south-eastern direction, after about 1250 m take the forest road in eastern direct after 250 m the road becomes Mathildedreef. At the end of this road the profile is located to the right about 25 m into the forest. Take care the forest is fenced with barbed wire.
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 17 *Code profile:* 505 *Latitude, longitude:* 51° 17' 11.11" N, 4° 36' 07.67" E
1.6 Elevation:	±19 m a.s.l.
2.1 Atmospheric climate and weather condition:	Sunny, 30-32°C. Heat wave during the 20 days prior to the fieldwork, possible one or two rain showers during this period.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The region is almost flat, with water streams running from north/north-east to south/south-west, towards the Albertkanaal, which drains into the Schelde river. Due to the almost flat terrain, peat landscapes are common in the region, some clearly scarred by peat exploration (figure 20 and 21). *Meso topography:* The profile site is located on a long gentle slope *Landscape position:* intermediate part of an almost flat terrain *Slope form:* SS (straight, straight) *Slope gradient:* ¼°, or 0.56% (Topografische Atlas Belgie, 1:50,000) *Slope length:* ± 7 km *Slope orientation:* dipping towards south-west
2.4 Land-use:	Plantation forestry with selective felling *Wildlife:* Not protected *Grazing:* No grazing
2.5 Human influence:	The vegetation appears undisturbed at present. In the past disturbance must have occurred when the ditches were constructed. The ditches are oriented north-south (run-off towards south) and are constructed with 6 meters interval (photo 22).
2.6 Vegetation:	Coniferous woodland with Scots Pine occupying >90% of species number. Mountain ash and black cherry occupies <10%.

Tree layer		**Shrub layer**		**Herb layer**	
Scots Pine	*Pinus sylvestris*	Black Cherry	*Prunus serotina*	Bilberry	*Vaccinium myrtillus*
		Mountain Ash	*Sorbus aucuparia*	Hair grass	*Deschampsia flexuosa*
		Alder Buckthorn	*Rhamnus frangula*	Wood Ferns	*Dryopteris dilatata*
				Common Hemp-nettle	*Galeopsis tetrahit*
				Mountain Ash	*Sorbus aucuparia*
				Purple Moor Grass	*Molinia caerulea*
				Pedunculate Oak	*Quercus robur*

2.7 Parent material:	Cover sand (7220)
2.8 Drainage class:	Well drained *Availability of water:* Insufficient
2.9 Internal drainage:	Never saturated
2.10 External drainage:	Neither receiving nor shedding water
2.12 Groundwater:	Extremely deep (>200 cm)
2.13 Rock outcrop:	None

2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	No erosion observed
2.17 Surface cracks:	No
Humus classification:	The forest floor is composed of loose OL layer, overlying a thick OF and a relatively thin OH. The horizon sequence is OL, OFnoz, OHnoz, E (photo 23). *Classification name:* Mor → Eumor
Remarks:	No stones through the profile

No.		**Horizon description** (see also photo 24)
H1	OL	-10 till -7 cm; mostly undecomposed needles and some mosses
H2	OFnoz	-7 till -1 cm; very dark greyish brown 10YR 3/2 (M) partly decomposed litter almost entirely composed of needles
H3	OHnoz	-1-0 cm; black to very dark brown 7.5YR 2.5/1.5 (M) decomposed litter
H4	Ap/E	0-25 cm; black 2.5Y 2.5/1 (M), dark grey to grey 10YR 4.5/1 (D); sand; single grain with salt and pepper distribution of uncoated sand and OM; very friable; common very fine to fine and few medium to coarse roots, strong preference for A or A+E horizon material on the cost of E horizon material; single time ploughed; single pottery fragment, 4 cm long; humus migration fibres, 1-3 cm thick, more or less horizontal, post-ploughing; smooth abrupt boundary
H5	E	25-32/56 cm; greyish brown to brown 10YR 5/2.5 (M), light brownish grey 10YR 6/2 (D); many to abundant (±40%), rounded, coarse (2-4 cm), distinct, sharp, light brownish grey to light grey (10YR 6.5/2) leopard-like mottles; sand; single grain; loose; no very fine, few fine and no medium to coarse roots; broken (tongues) abrupt boundary
H6	Bh	25-41/80 cm; black 10YR 2/1 (M), very dark grey to very dark greyish brown 10YR 3/1.5 (D); many (20-30%), irregular rounded, coarse (2-4 cm), prominent, sharp, dark greyish brown (10YR 4/2, M) leopard-like mottles[1]; sand; single grain; very friable; common very fine to fine and few medium to coarse roots; few bio galleries (±15mm dia.), filled with a mix of the A+E horizon material and extending into the horizon below; complex (tongues) clear boundary
H7	Bhs	41/46-49/68 cm; very dark grey to dark brown 7.5YR 3/1.5 (M), brown 8.5YR 4/3 (D); many (30-40%), medium to coarse (1-4 cm), prominent, sharp, brown (10YR 5/3, M) leopard-like mottles; sand; single grain; very friable; common very fine to fine, few medium and very few coarse roots; broken and wavy, clear boundary
H8	Bs	49/62-63/71 cm; dark yellowish brown 10YR 4/4 (M); yellowish brown 10YR 5/4 (D); sand; single grain; loose; common very fine and few fine to medium roots; irregular abrupt boundary
H9	BC	63/80-86 cm; yellowish brown to light olive brown 1.5Y 5/4 (M), very pale brown to pale yellow 1.5Y 7/4 (D); common (10-15%), medium (1-2 cm), faint, light greyish leopard-like mottles, and where clay has weathered rusty brown, diffuse mottles; sand, heterogeneous texture with clayey zone in a sandy matrix; single grain; friable; very few very fine roots; diffuse humus bands, irregular distributed though the horizon; smooth abrupt boundary
H10	2C	86-91/110 cm; light yellowish brown 2.5Y 6/3 (M), light grey 2.5Y 7/2 (D); common to many (20-25%), irregular, distinct, diffuse, oxido-reduction and clay weathering mottles; loam; massive; friable; very few fine to medium roots; cryoturbation involutions of underlying horizon into this one; wavy abrupt boundary
H11	3C1	91/110-127 cm; yellowish brown to light yellowish brown 10YR 5.5/4 (M), very pale brown 10YR 7/4 (D); sand; single grain, horizontally stratified; loose; no roots; frost crack, dia. 4-5 mm, crossing diagonal through H11-13, filled with light beige material; smooth gradual boundary
H12	3C2	127-145 cm; yellowish brown to light olive brown 1.5Y 5/4 (M), light yellowish brown 1.5Y 6/4 (D); sand; single grain; loose; no roots; smooth clear boundary
H13	4C	145-… cm; yellowish brown to light olive brown 1.5Y 5/6 (M), brownish yellow to olive yellow 1.5Y 6/6 (D); sand; single grain; loose; no roots

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

[1] Leopard-like mottles= due to bacterial consumption of the organic material present in the soil matrix, rounded mottles are formed. Such mottles are commonly found in well drained Podzol like soils although they also are found in other sandy soil types.

Photo 21: View inside the forest hosting profile 505 (Photo JM)

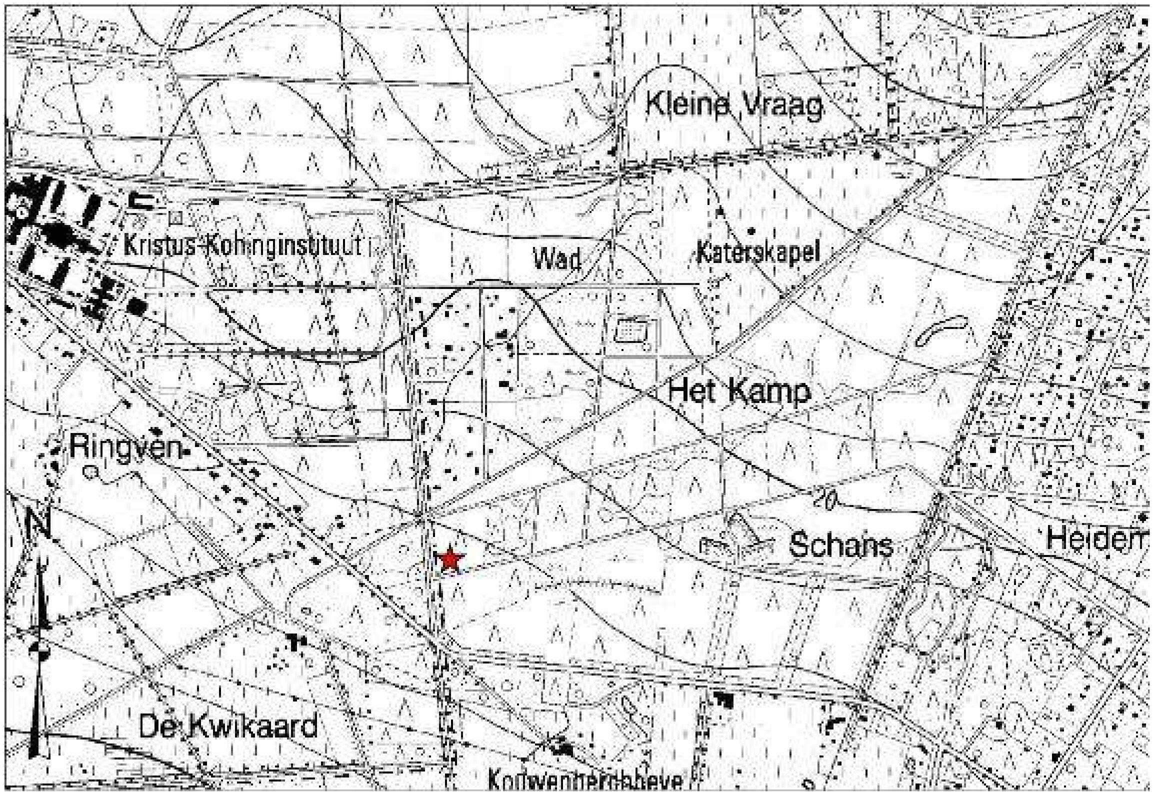

Figure 21: Detailed topographical map of the surroundings of soil profile 505 (Schilde)

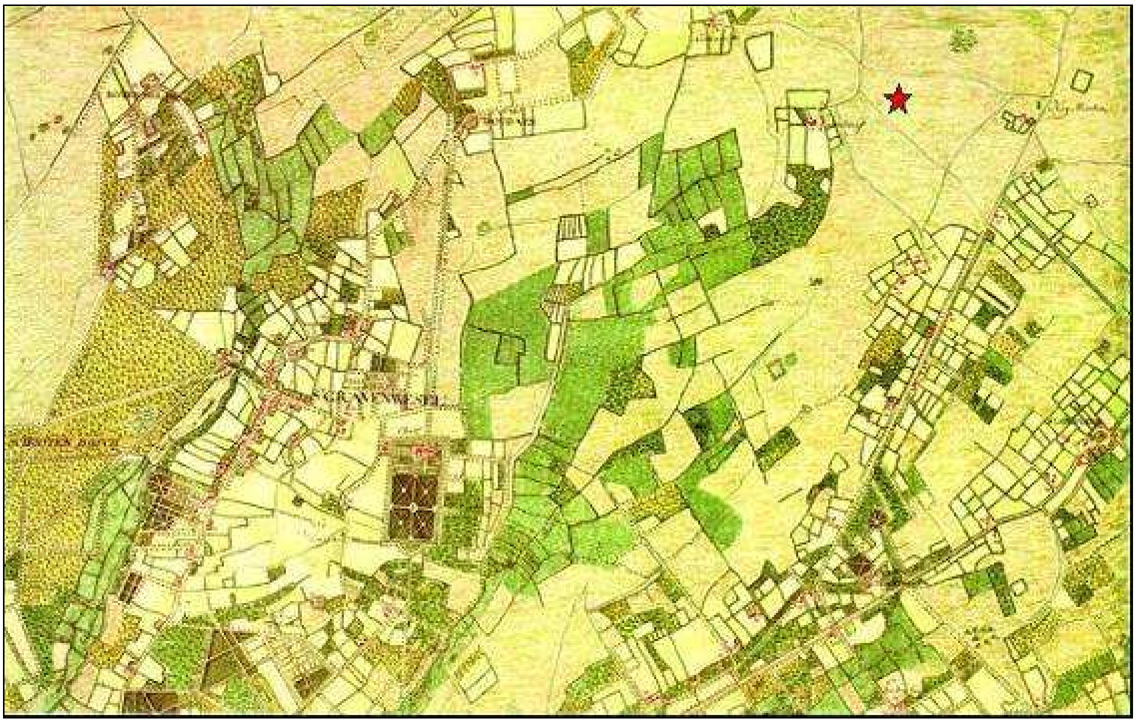

Figure 22: Ferraris map (1777) of the area surrounding the forest plot in Schilde

During the time the Ferraris (1777) map was drawn heath land was prominent in the surroundings of profile 505, later coniferous forests were planted. Profile 505 is located more or less in the area of the red star. Lack of permanent roads and other geographical reference points makes a precise location difficult.

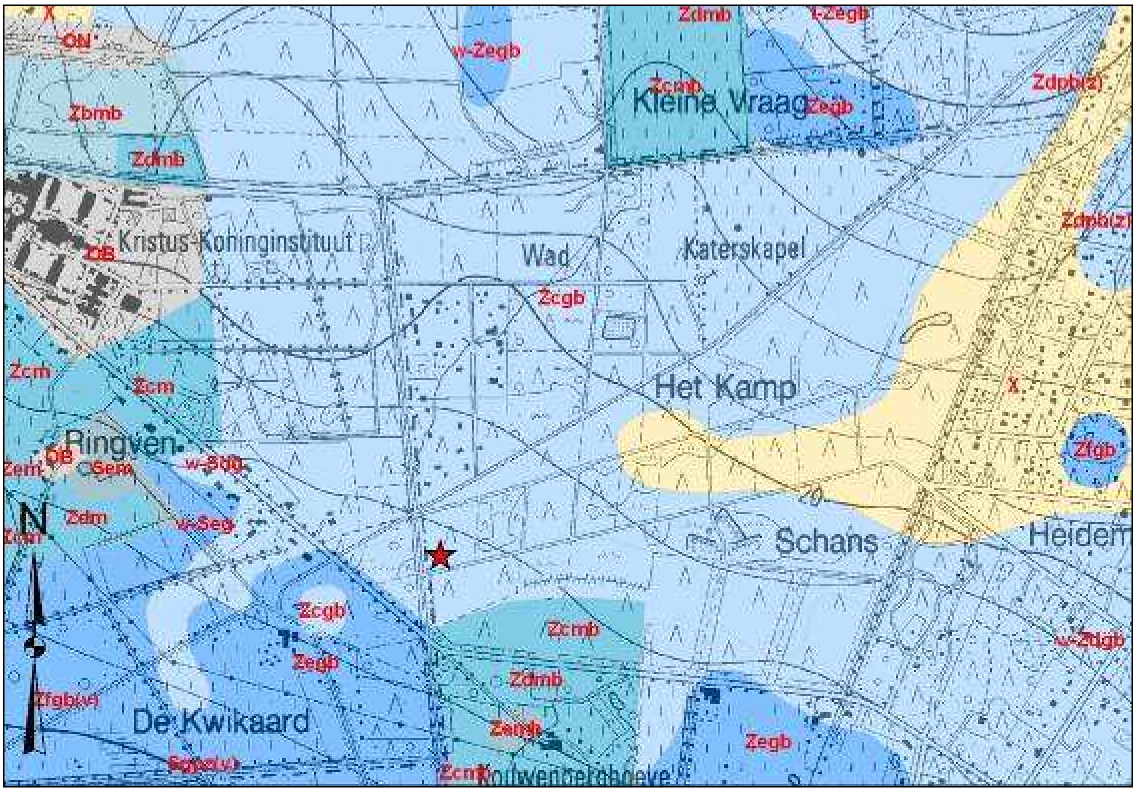

Figure 23: Soil map of the surroundings of P505, Schilde. The sandy nature (bluish colours) of the area is obvious.

Photo 22: View on the immediate surroundings of profile 505 (Photo JM)

Photo 23: The humus layers are relatively well developed in profile 505. The humus was classified as Eumor.

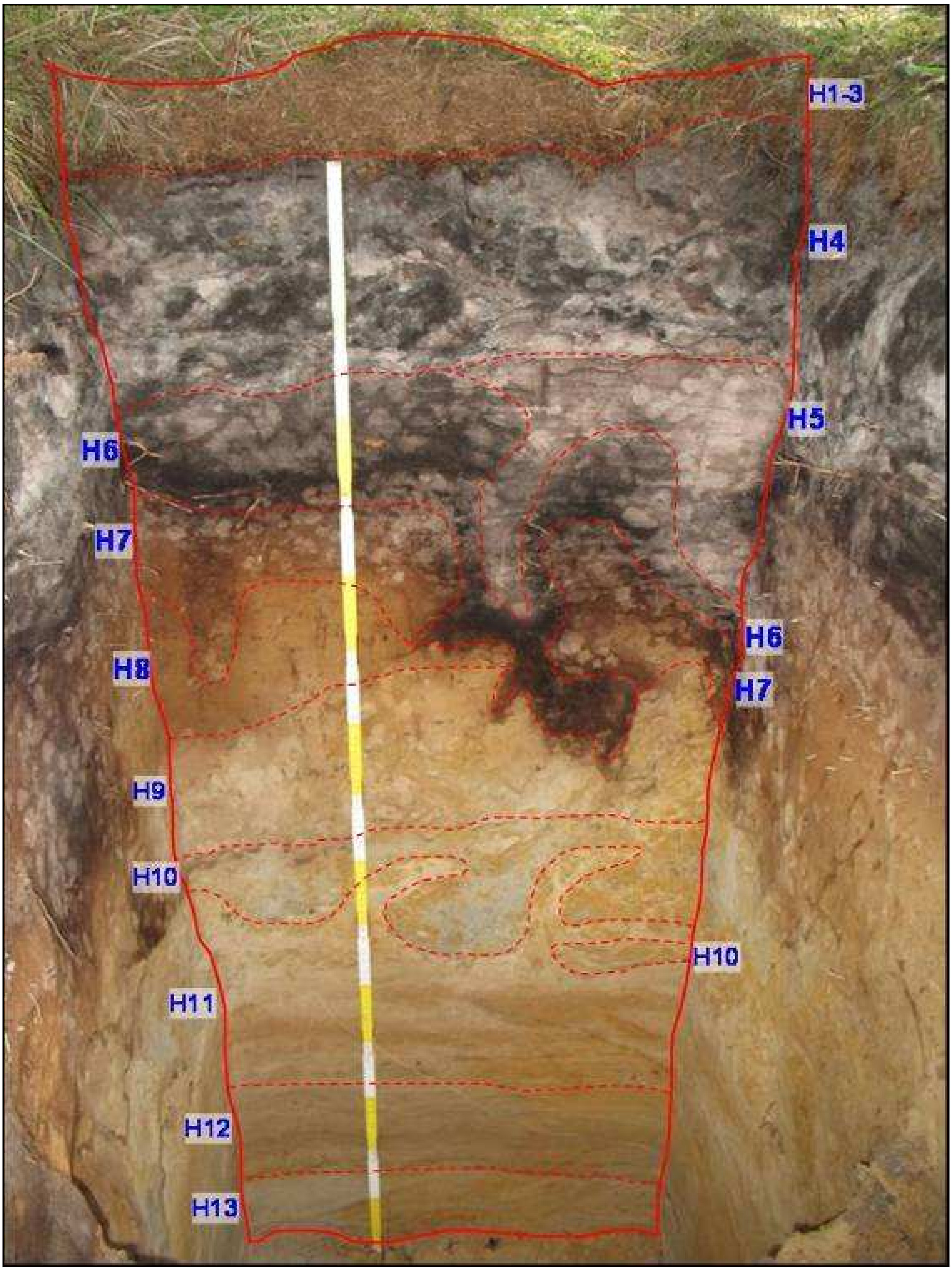

Photo 24: Soil profile 505 with the horizons indicated. Notice the periglacial forms of H10-11, they are remains of a past colder period.

9.2. Analytical data

The content of nitrogen is relatively low through the soil resulting in C/N ratios of 26-42. In H5, the E horizon, the C/N ratio is 10 due to a very low content of organic carbon. The soil is rather acid with pH-H_2O in the range of 3.4-4.5 (Table 17). A very small content of coarse fragments present in the upper horizons is composed of organic fragments, sand cemented by iron into relatively soft nodules and very fine gravels. H4-9 have a homogeneous particle size distribution. H10 is very different with a high clay content and more than 35% silt.

Table 18: Analytical data for profile 505, Schilde, Province of Antwerp, Belgium. Profile studied 24-25/7/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	**Horizon symbols**	**Depth** cm	**Total N** (Kjeldahl) **Modified** %	**Standard** %	**Org. Carbon TOC** %	**W&B** %	**OM LOI** %	**pH H_2O 1:1**	**H_2O 1:5**	**$CaCl_2$ 1:5**	**Coarse frag. >2mm** %-wght
1	OL	10-7									
2	OF	7-1	1.637				87		3.4	2.6	
3	OH	1-0	1.059				57		3.4	2.6	
4	Ap	0-25	0.047	0.056	1.95	1.7			4.0	3.1	0.2
5	E	25-32/56	0.023	0.015	0.23	0.4			4.2	3.7	0.4
6	Bh	25-41/80	0.074	0.071	1.97	2.5			3.9	2.9	0.2
7	Bhs	41/46-49/68	0.077	0.043	0.97	0.7			4.0	3.4	0.6
8	Bs	49/62-63/71			0.96	0.5			4.2	3.9	0.9
9	BC	63/80-86			0.39	0.3			4.4	4.2	0.3
10	2C	86-91/110			0.23	0.5			4.3	4.0	0.0
11	3C1	91/110-127			0.16	<0.1			4.5	4.4	0.0
12	3C2	127-145			0.16	<0.1			4.5	4.3	0.0
13	4C	145-…			0.06	<0.1			4.5	4.3	0.0

Horizon nr.	**Particle size distribution (fractions in µm)** ---%--- **0-2**	**2-10**	**10-20**	**20-50**	**50-63**	**63-100**	**100-125**	**125-250**	**250-500**	**500-1000**	**1000-2000**
1											
2											
3											
4	0.5	1.3	0.8	6.6	1.6	7.6	7.3	52.8	19.5	0.8	1.0
5	0.8	0.3	1.4	6.0	1.2	6.9	6.2	53.3	22.7	0.6	0.1
6	1.3	1.0	1.4	7.0	1.0	8.1	7.6	55.2	16.7	0.5	0.1
7	1.9	0.3	1.7	7.1	1.1	8.8	7.9	52.1	18.1	0.6	0.1
8	1.3	0.5	0.6	8.5	1.3	8.5	7.6	50.2	20.1	0.8	0.2
9	1.3	0.1	0.7	7.5	1.9	9.7	8.9	50.7	18.1	0.9	0.2
10	12.4	6.0	5.3	25.1	2.7	11.9	4.8	22.7	8.6	0.3	0.0
11	1.4		0.8		0.1	1.3	3.0	64.9	28.2	0.3	0.0
12	1.6		1.0		0.4	5.2	11.0	74.2	6.4	0.2	0.0
13	1.4		0.6		0.2	0.2	0.4	35.3	59.5	2.4	0.0

Horizon nr.	**Mg++**	**Na+**	**K+**	**Ca++**	**CEC** (by NH_4OAc, cmol(+)/kg soil')	**BS** %	**CEC/ clay**	**Al** Dithi. Citrate %	**Fe** Dithi. Citrate %	**Al** Oxalate %	**Fe** Oxalate %
1											
2	1.20	<0.22	0.51	4.66	72.9	<9				0.042	0.068
3	0.93	<0.22	0.44	3.59	62.1	<8				0.059	0.086
4	0.06	<0.22	<0.13	0.09	3.9	<9		0.003	0.029	0.011	0.015
5	0.05	<0.22	<0.13	0.05	0.5	<55					
6	0.05	<0.22	<0.13	0.09	9.6	<3		0.085	0.048	0.067	0.030
7	0.06	<0.22	<0.13	0.07	5.0	<6		0.108	0.044	0.081	0.017
8	0.05	<0.22	<0.13	0.06	5.0	<6		0.157	0.055	0.118	0.013
9	0.06	<0.22	<0.13	0.05	2.4	<12		0.095	0.076	0.114	0.017
10	<0.28	<0.22	<0.13	<0.5	5.8	<10	40	0.140	0.189	0.139	0.084
11	<0.28	<0.22	<0.13	<0.5	1.4	<41					
12											
13											

Horizon nr.	**Horizon symbols**	**Depth** cm	**Mg++** (by $MgSO_4$ (compulsive method), cmol(+)/kg soil)	**Na+**	**K+**	**Ca++**	**Al+++**	**Fe+++**	**Mn++**	**Free H+**	**Lab nr.**
1	OL	10-7									JM153
2	OF	7-1	<0.61	<0.09	0.54	6.31	1.51	0.18	0.112	9.60	JM154
3	OH	1-0	<0.58	<0.09	0.44	4.46	2.54	0.25	0.058	9.25	JM155
4	Ap	0-25	<0.12	<0.02	0.02	0.03	0.63	0.03	<0.002	0.92	JM156
5	E	25-32/56	<0.12	<0.02	<0.01	<0.02	0.06	<0.01	<0.002	0.18	JM157
6	Bh	25-41/80	<0.12	<0.02	0.01	0.04	3.42	0.05	<0.002	1.17	JM158
7	Bhs	41/46-49/68	<0.13	<0.02	0.01	0.02	2.75	0.01	<0.002	0.34	JM159
8	Bs	49/62-63/71	<0.12	<0.02	0.01	<0.02	2.54	<0.01	<0.002	0.14	JM160
9	BC	63/80-86	<0.12	<0.02	<0.01	<0.02	1.20	<0.01	<0.002	0.03	JM161
10	2C	86-91/110	<0.12	<0.02	0.08	<0.02	3.69	0.01	<0.002	0.08	JM162
11	3C1	91/110-127	<0.12	<0.02	<0.01	<0.02	0.73	0.01	<0.002	0.02	JM163
12	3C2	127-145									JM164
13	4C	145-…									JM165

Table 17 (continued): Analytical data for profile 505, Schilde, Province of Antwerp, Belgium. Profile studied 24-25/7/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
	cmol(+)/kg		%	cmol(+)/kg		Aqua Regia mg/kg					
1						784	2346	353	140	680	2368
2	18.3	<18	80	11.4	11.5	376	1250	233	80	498	2762
3	17.0	23.3	22	12.1	12.2	347	1039	183	54	374	2004
4	1.6	<4	6	1.6	2.2	159	96	30	45	26	49
5	0.2	<4	4	0.2	0.4	199	50	25	36	11	16
6	4.7	5.2	2	4.6	6.0	288	147	98	41	70	87
7	3.1	<4	6	3.1	3.2	407	241	206	42	72	76
8	2.7	<3	6	2.7	2.7	440	257	245	55	92	178
9	1.2	<3	6	1.2	1.4	439	122	377	27	42	44
10	3.9	4.0	4	3.8	4.0	1406	170	1017	52	39	80
11	0.8	<4	4	0.8	0.9	310	68	193	23	23	17
12						623	75	329	30	26	25
13						368	68	201	24	20	12

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	CaCO3
	Aqua Regia mg/kg									dS/m 1:5	%
1	672	1.39	12.9	858	145	2	36.2	5.3	96		
2	1165	1.20	18.7	1833	42	4	88.1	9.1	81	0.15	
3	1435	1.08	27.8	2352	34	6	170.8	11.2	67	0.07	
4	748	0.08	1.1	342	4	6	6.9	0.4	6	0.03	
5	677	0.01	<	153	5	3	1.2	0.1	4	0.02	
6	2369	0.28	<	854	8	6	3.9	0.7	7	0.05	
7	3203	0.11	<	1467	11	7	3.0	0.8	8	0.04	
8	3851	0.09	0.0	1692	13	8	1.9	1.0	7	0.03	
9	4332	0.04	0.3	3141	7	6	1.9	1.5	9	0.02	
10	10950	0.08	3.2	7246	14	19	5.2	3.7	23	0.04	
11	2362	0.01	0.2	1622	2	3	1.0	0.7	7	0.02	
12	3614	0.01	0.6	2467	3	6	1.7	1.1	9	0.02	
13	2285	0.02	0.5	2088	2	4	1.3	0.7	9	0.02	

H11-13 are very sandy as well but the relative distribution is different than for H4-9. As an example H13 has 3 times more sand in the fraction 250-500 µm. The textural pattern of H10-13 clearly reflects different parent materials.

The content of cations extracted by the method of ammonium acetate is very low, mostly lower than the detection limit of the laboratory. Except for the litter layers, the CEC does not exceed 10 (cmol(+)/kg soil). This obviously reflects the low content of clay but also that the organic matter present has a low CEC. It is evident from the data that this soil only can store a very limited amount of nutrients (Table 17).

The content of cations extracted by the triple $BaCl_2$ method shows very low contents for the basic cations, iron and manganese. On the other hand, high contents for aluminium are seen, especially in the subsoil. Without the litter layer this soil has as good as no cations as they are all stored in the organic top layer. Below we find base saturations of 2-6%, which is very limiting for any plant growth.

Both data on dithionite and oxalate extractable iron and aluminium are available. The contents are relatively low. No peak is found in the content of oxalate iron and aluminium for the Podzol B horizons as it can be expected (surely for the Bs horizons). Not surprisingly the highest contents are present in H10, which is also the horizon with the highest clay content.

The aqua regia extractable elements show the expected trends, with very high contents in the litter layer and a peak in H10 due the higher clay content here.

The bulk density, with values between 1.3 and 1.5, is relatively low considering that the soil is nearly entirely composed of sand (Table 18). A fast drop in the water holding capacity is registered in the range around field capacity, which implies that after a few weeks of drought the vegetation will suffer under lack of water (Table 18 and Figure 24).

Table 19: Bulk density and water holding capacity for profile 505, Schilde

Horizon nr.	Horizon symbols	Depth cm	Actual water cont. %	BDs soil g/cm3	BDFE fine earth g/cm3			Lab nr.
1	OL	10-7	35					JM153
2	OF	7-1	117					JM154
3	OH	1-0	95					JM155
4	Ap	0-25	6	1.32	1.31			JM156
5	E	25-32/56	2					JM157
6	Bh	25-41/80	8	1.44	1.44			JM158
7	Bhs	41/46-49/68	5	1.42	1.42			JM159
8	Bs	49/62-63/71	6	1.42	1.42			JM160
9	BC	63/80-86	5	1.51	1.50			JM161
10	2C	86-91/110	16					JM162
11	3C1	91/110-127	5					JM163
12	3C2	127-145	14					JM164
13	4C	145-...	9					JM165

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	---------- Vol. % water ----------							
1								
2								
3								
4	49.3	47.7	33.8	10.4	9.2	8.4	6.1	3.2
5								
6	53.4	51.5	44.3	21.4	18.9	17.4	6.2	4.1
7	53.1	52.6	47.9	21.3	19.0	17.5	4.2	2.1
8	53.3	52.2	46.6	16.3	14.6	13.4	5.6	4.3
9	47.4	47.2	41.8	11.6	8.9	8.3	4.0	2.7
10								
11								
12								
13								

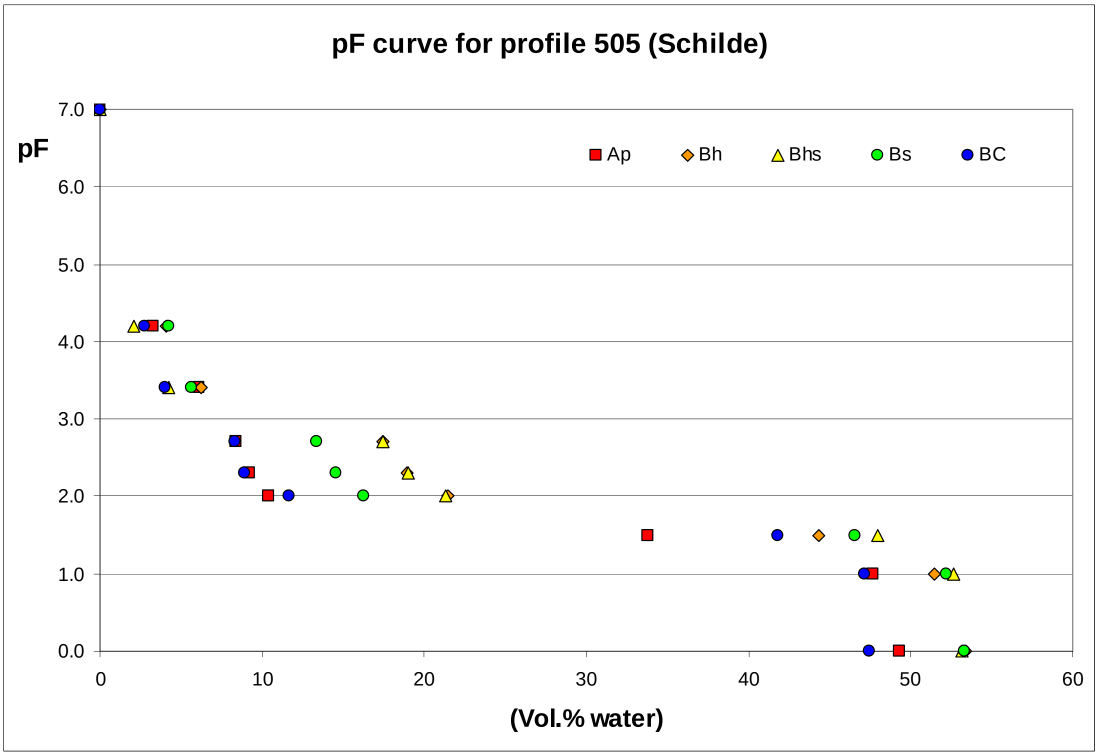

Figure 24: PF curve for profile 505. The horizons analysed are characterised by a low content of water in between field capacity and wilting point (pF 2.0-2.5 and 4.2)

9.3. Information deduced from the Belgian soil map

Soil profile 505 is located on soil map Brecht 16W (De Coninck and Tavernier, 1958) and is situated within the 'Antwerpse Kempen' a sandy region extending towards the border with the Netherlands and beyond (Figure 23). The experimental plot is found on soil type Zcg, with to the south w-Zdg. Zcm units are found through the soilscape characterised by their squared form (plaggen fields). Inland dunes are common too on the soil map, most probably they are old areas of outfields (heather) that has been over-exploited as part of the 'plaggen' system (or sod-cutting) resulting in erosion of the topsoil (Table 19).

Table 20: The soil map units of soil profile 505, Schilde, and in the immediate surroundings (after De Coninck and Tavernier, 1959).

Map unit	Concise explanation:
Zcg	Well drained fine sandy soils with well developed humus and/or iron B horizon. The soils are described as humus Podzols with a firm to very firm Bh or Bhs horizon overlying a Cg horizon.
w-Zdg	Moderately well drained sandy soils with a clear humus and/or iron B horizon. Clayic sand substratum present at shallow depth (<80 cm)
Zcm	Well drained sandy soils with deep anthropogenic humus A horizon. The soil have a broken Bt or a Bhs subsoil horizon.
X	Inland dunes

9.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H5, H10	
Folic	H1-3	
Spodic	H6-7	Where H5 rest in top of H6-7 the Spodic is qualifying. Where H5 is absent it is a question if cracked coatings are present. Morphologically and logically it should qualify because where the Albic is missing, it is due to a single time ploughing event prior to the afforestation. The Albic is present where it was originally deeper than the ploughing depth. Consulting the photo it seems reasonable that the Albic is present not only as H5 but also in pockets in H4.
Umbric	H4	Thickness exactly 25 cm which is enough. Colour mixed is 2.5Y 2.5/1 and dry 10YR 4.5/1. Unmixed the colour moist is 2.5Y 2.5/1 for the blackish A parts and 10YR 6.5/2 for the E parts.
Abrupt textural change	H9-10	
Gleyic colour pattern	H10	
Lithological discontinuity	Between H9-10 Between H10-11 Between H12-13	Based on abrupt increase in clay from 1.3 to 12.4% Based on relative change in sand ratios. Medium sand increases from 8.6 to 28.2% and fine sand increases from 39.4 to 69.2%. Based on relative change in sand ratios. Fine sand decreases from 90.4 to 35.9% and medium sand increases from 6.4 to 59.5%.

Simplified classification name
Albic Podzol • The Spodic horizon is composed of H6 and H7, as H7 turns redder upon ignition and H6 not, it seems most logic not to use the qualifiers Carbic nor Rustic

Full classification name without specifiers
Umbric Folic Albic Podzol (Ruptic) • Turbic is not applied as it appears just below 100 cm and anyway it is a relict of past glacial period, which implies it is inactive today

BioSoil classification name (WRB 2006), with specifiers
Hypoumbric Hypofolic Albic Podzol (Endoruptic) • Umbric with specifier hypo because it is just exactly 25 cm thick (and this only due to a single time ploughing)

9.5. Discussion

This soil is typical for the cover sand region of northern Belgium. The soil has a sandy particle size distribution with a thin more clayey layer in depth. Due to the general very low content of clay and the poor type of organic matter mostly related to the pine forest, the nutrition carrying capacity of the soil is very low. In such sandy and nutrition poor soils the development of a Podzol is evident, which is also the case for this profile. Often such soils are not classified as Podzols because of anthropogenic influence mostly in form of ploughing. In case of profile 505 indeed the upper 25 cm of the mineral soil is an old plough layer. By ploughing this soil the original A and E horizons were mixed. Prior to the ploughing the E horizon may have had a considerable thickness, as even after ploughing a layer of 7-8 cm is present below the plough layer. Due to the ploughing the Ap horizon qualifies for Umbric, which is odd, considering that soils with an Umbric horizon rather would have a high production of organic matter with a good biological activity making sure that the organic matter would be mixed into the subsoil. In this soil there is no faunal mixing of the litter layer with the underlying mineral soil, which has resulted in the development of an Eumor, which is the type of mor with the lowest fertility.

The WRB-2006 soil classification name in this study correlates well with the FAO (1988) soil classification name of 'Haplic Podzols' given by the soil surveyors in 1993.

10. Profile 602, Beerse, Antwerp

10.1. Site and profile description

Profile 602	**Beerse (Level I forest plot)**
1.2 Date of description:	21/6/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Antwerp, Beerse Municipality On highway E34 take exit 22 direction Beerse along N132 (Beersebaan). After 1250 m turn left along a gravel road (Beerseheide). Follow this road for 1350 m, at the end turn left. Drive for 100-150 m and turn right. The forest on the left side is the level 1 plot (photo 25). Park the car on the dirt road between the forest and the farm.
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 18 *Code profile:* 602 *Latitude, longitude:* 51° 17' 25.86" N, 4° 50' 09.61" E (centre profile pit)
1.6 Elevation:	20-21 m a.s.l.
2.1 Atmospheric climate and weather condition:	No information
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The forest plot is located in a very gently rolling landscape, with on the higher parts traditionally heather vegetation. Today the heath lands are often afforestated. The lower parts of the landscape, the tributary valleys are characterised by permanent grassland. The level 1 forest plot is situated within an afforestated area (Photo 25). *Meso topography:* Ditches present with mutual distance of 6 m, west-east oriented. The ditches are dating from when the forest was planted. *Landscape position:* intermediate part of an almost flat landscape. The higher parts peak at about 30 m, the valley is found at 12.5-15 m altitude (Figure 25 and 26). *Slope form:* - *Slope gradient:* - *Slope length:* about 9000 m *Slope orientation:* Dipping towards SE
2.4 Land-use:	Plantation forestry with selective felling. No grazing and probably no protection of the wildlife
2.5 Human influence:	Vegetation slightly disturbed.
2.6 Vegetation:	Coniferous woodland with >50% Scots Pine

Tree layer		**Shrub layer**		**Herb layer**	
Scots Pine	*Pinus sylvestris*	Black Cherry	*Prunus serotina*	Brambles	*Rubus sp.*
		Mountain Ash	*Sorbus aucuparia*	Wood Ferns	*Dryopteris dilatata*
		Silver Birch	*Betula pendula*	European Honeysuckle	*Lonicera periclymenum*
		Alder Buckthorn	*Rhamnus frangula*	Mountain Ash	*Sorbus aucuparia*
		Pedunculate Oak	*Quercus robur*	Purple Moor Grass	*Molinia caerulea*

2.7 Parent material:	Coversand (7220)
2.8 Drainage class:	Somewhat excessively drained *Availability of water:* insufficient
2.9 Internal drainage:	Never saturated
2.10 External drainage:	Never receiving nor shedding
2.12 Groundwater:	Actual GWT at 185 cm depth below the mineral surface
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None

2.15 Erosion, sedimentation:		None
2.17 Surface cracks:		None
Humus classification:		The soil is composed of a relatively thin OL layer a thick OF layer and a thick OH layer. The horizon sequence is OL, OFnoz, OHnoz, E (photo 26). *Classification name:* Mor → Eumor
Remarks:		It is assumed that the heterogeneity of H3 is due to a single ploughing event dating from before planting of the Scots Pines. The planting may also explain why the Bh horizon appears locally broken. H5-6 turns redder upon ignition, H4 not.
No.		**Horizon description** (see also photo 28)
H1	OL	$^{-}$10-$^{-}$9 cm;
H2	OF	$^{-}$9-$^{-}$3 cm; dark brown 7.5YR 3/2 (M)
H3	OH	$^{-}$3-0 cm; black to very dark brown 7.5YR 2.5/1.5 (M); smooth abrupt boundary
H4	A/E	0-11/22 cm; dark greyish brown 10YR 4/2 (M); greyish brown 10YR 5/2 (D); very dark brown 10YR 2/2 (W); no reaction to α,α-dipyridyl; sand; single grain; loose; few very fine to fine and very few medium to coarse roots; humus migration fibres; several visible spade marks, where part of the underlying horizon has been included in this horizon; complex abrupt boundary
H5	Bh	11/22-30 cm; very dark brown 10YR 2/2 (M); very dark grey 10YR 3/1 (D); no reaction to α,α-dipyridyl; sand; single grain; with salt and pepper distribution of uncoated sand and OM; slightly hard; few very fine to fine roots; smooth clear boundary
H6	Bhs	30-39/45 cm; dark brown 7.5YR 3/2 (M); brown 10YR 4/3 (D); no reaction to α,α-dipyridyl; sand; single grain; soft; few very fine to fine and very few medium to coarse roots; smooth clear boundary
H7	Bw	39/45-61/65 cm; yellowish brown to light olive brown 1.5Y 5/4 (M); light yellowish brown 1.5Y 6/4 (D); very few, medium, (±20 mm), distinct, clear, pale yellow 2.5Y 7/4 (M) leopard-like mottles[1]; no reaction to α,α-dipyridyl; sand; single grain; loose; few very fine and very few fine roots, one horizontal growing coarse root of ±10mm; smooth gradual boundary
H8	C	61/65-86/103 cm; light olive brown to light yellowish brown 2.5Y 5.5/4 (M); pale yellow 2.5Y 7/4 (D); 2.5Y 5.5/4 (W); no reaction to α,α-dipyridyl; sand; sub-rounded, fresh, fine gravels, concentrated in a horizontal layer of 1-2 cm thickness at about 88 cm depth; single grain, with stratification still visible; horizontal Bt fibres in upper part; very friable; very few very fine roots, present until about 70 cm depth; smooth clear boundary
H9	Cg1	86/103-94/104 cm; light yellowish brown 2.5Y 6/4 (M); light yellowish brown 1.5Y 6/4 (D); light olive brown to light yellowish brown 2.5Y 5.5/4 (W); no reaction to α,α-dipyridyl; sub-angular, fresh, fine gravel and very coarse sand, particular common in left side of the profile; single grain, the horizon is a stratification layer of coarser material; very friable; smooth clear boundary
H10	Cg2	91/104-105/117 cm; yellowish brown to light olive brown 1.5Y 5/6 (M); pale yellow 2.5Y 7/4 (D); very few (1-3%, left side) to many (25-30%, right side), coarse (30-40mm), prominent, diffuse (up to 10mm) strong brown 7.5YR 4/7 (M) mottles; no reaction to α,α-dipyridyl; loamy sand; single grain, stratification visible; very friable; wavy clear boundary
H11	Cr1	105/117-162 cm; light brownish grey to light olive grey 3.5Y 6/2 (M); light grey to pale yellow 3.5Y 7/2.5 (D); light olive brown 2.5Y 5/3 (M) mottles; positive reaction to α,α-dipyridyl; loamy sand; single grain; very friable; smooth abrupt boundary
H12	Cr2	162-… cm; brown to light olive brown 1.5Y 5/3 (M); very pale brown to pale yellow 1.5Y 7/3.5 (D); positive reaction to α,α-dipyridyl from about 180 cm depth; loamy sand; single grain, visible stratification; non sticky, non plastic

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

[1] Leopard-like mottles= due to bacterial consumption of the organic material present in the soil matrix, rounded mottles are formed. Such mottles are commonly found in well drained Podzol like soils although they also are found in other sandy soil types.

Photo 25 (left): Edge of the forest plot hosting profile 602 (Photo JM)
Photo 26 (right): Soil profile 602 with the surrounding vegetation. Due to the rather open canopy sufficient light is available for a relatively dense shcrub vegetation (Photo JM)

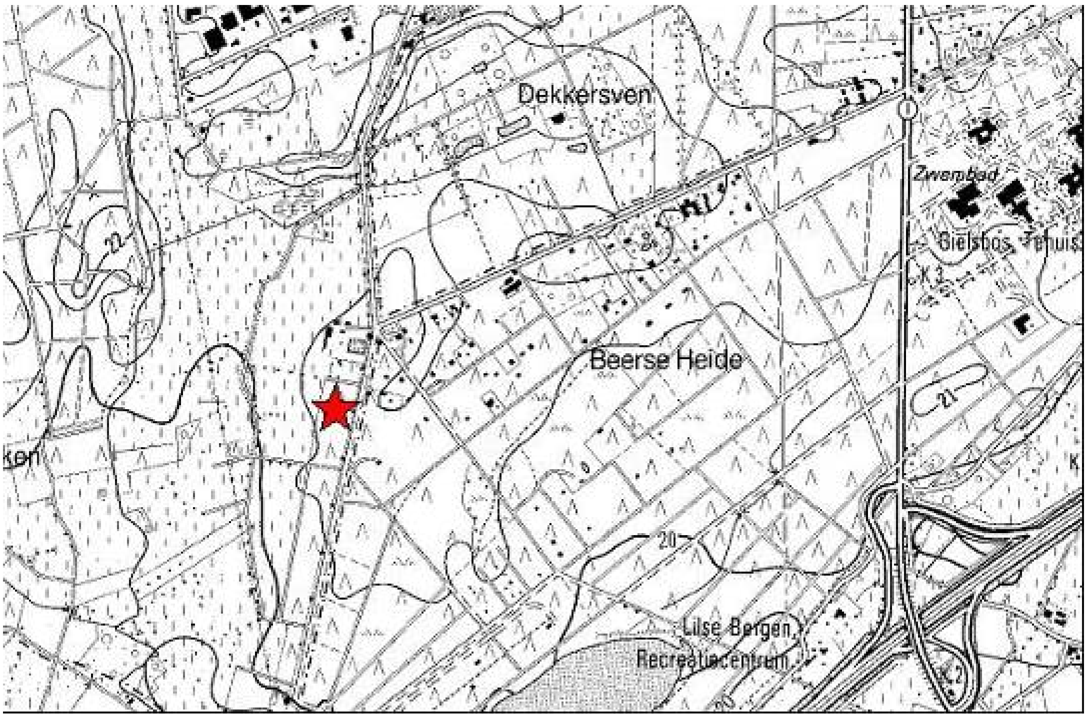

Figure 25: Location of profile 602, indicated with a red star, on the transition between the valley (west) and the Beerse Heide (east).

Figure 26: Detail of an Orthophotographical map of the Beerse Heide (heath land). The location of profile 602 is indicated with a red star.

Photo 27: Detailed view on the humus layers of profile 602. The forest floor is classified as an Eumor.

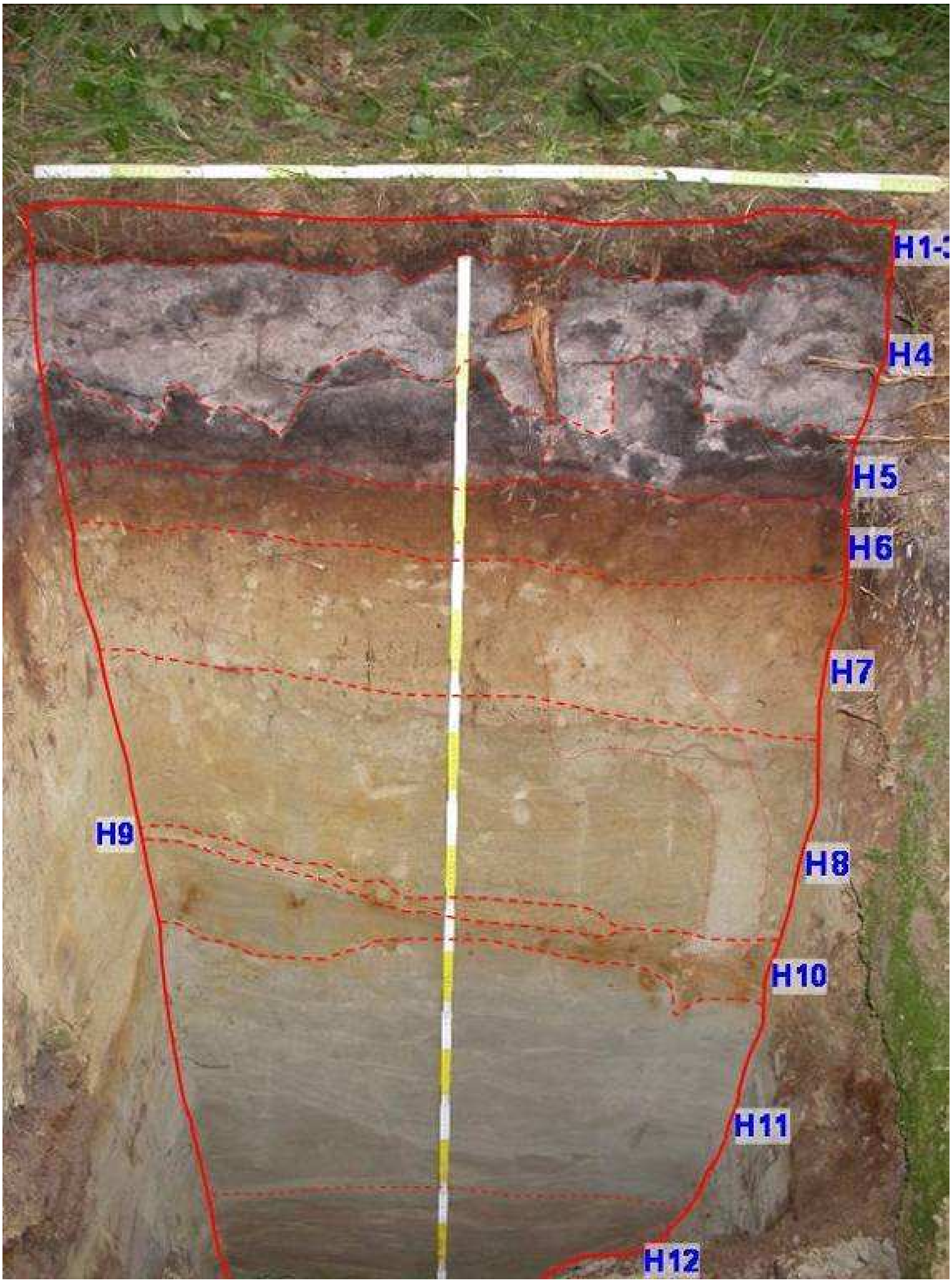

Photo 28: Profile 602 with the 12 horizons recognised in the field

10.2. Analytical data

The C/N ratio is extremely high with values from 22-34. From H7 it drops to 13, and that is only because the content of organic carbon drops to 0.3% (Table 20). Remarkable is the very high content of organic carbon in the Bh horizon with 3%, the high content is also reflected in the colour very dark brown (10YR 2/2). The pH is very low with values in the upper horizons between 3.4-3.7, increasing with depth to values around 4.2-4.6. A very small content of coarse fragments is related to coarse fragments of organic matter, such as roots, cementations and very fine gravels.

Table 21: Analytical data for profile 602, Beerse, Province of Antwerp, Belgium. Profile studied 21/6/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Standard %	Org. Carbon TOC %	W&B %	OM LOI %	pH H_2O 1:1	H_2O 1:5	$CaCl_2$ 1:5	Coarse frag. >2mm %-wght
1	OL	10-9									
2	OF	9-3	1.665				92		3.7	2.8	
3	OH	3-0	1.029				71		3.4	2.5	
4	A/E	0-11/22	0.037		1.15	1.0			3.8	3.0	0.1
5	Bh	11/22-30	0.107		3.03	2.9			3.6	3.0	0.1
6a	Bhs										0.4
6	Bhs	30-39/45	0.055		1.25	1.3			3.9	3.6	0.1
7	Bw	39/45-61/65	0.022		0.30	0.2			4.2	4.1	0.2
8	C	61/65-86/103			0.23	<0.1			4.6	4.4	0.1
9	Cg1	86/103-91/104			0.14	<0.1			4.3	4.2	0.8
10	Cg2	91/104-105/117			0.15	<0.1			4.2	4.1	0.0
11	Cr1	105/117-162			0.06	<0.1			4.2	4.1	0.0
12	Cr2	162-...			0.03	<0.1			4.3	4.0	0.0

Horizon nr.	Particle size distribution (fractions in µm) 0-2 %	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
1											
2											
3											
4	1.0	0.4	0.8	5.9	1.8	10.1	1.5	60.9	15.7	1.5	0.2
5	1.5	1.3	0.7	5.3	1.1	7.3	10.4	54.6	16.2	1.4	0.2
6a											
6	1.5	0.1	0.5	3.5	1.1	9.1	11.9	45.9	25.2	1.1	0.1
7	1.0	0.1	0.2	1.9	1.0	9.9	13.5	59.1	12.4	0.7	0.2
8	1.3	0.8	0.7	9.1	2.0	7.5	13.5	56.1	8.4	0.4	0.0
9											
10	4.1	0.9	0.6	6.2	3.5	19.8	16.5	41.8	5.6	0.6	0.1
11	3.8	0.3	0.1	9.5	4.2	20.7	17.3	39.5	4.1	0.2	0.0
12	4.3	0.1	0.8	13.9	4.1	16.1	14.3	40.6	5.2	0.3	0.0

Horizon nr.	Mg^{++} (by NH_4OAc, cmol(+)/kg soil)	Na^+	K^+	Ca^{++}	CEC	BS %	CEC/ clay	Al Dithi. Citrate %	Fe Dithi. Citrate %	Al Oxalate %	Fe Oxalate %
1											
2	1.70	0.31	0.62	5.89	73.2	12				0.040	0.066
3	1.80	0.23	0.34	4.95	87.1	8				0.076	0.158
4	0.08	<0.22	<0.13	0.10	2.9	6		0.017	0.015	0.015	0.008
5	0.05	<0.22	<0.13	0.10	13.4	1		0.174	0.019	0.192	0.016
6a								0.237	0.012	0.269	0.010
6	0.05	<0.22	<0.13	0.06	8.6	1		0.242	0.008	0.272	0.006
7	0.05	<0.22	<0.13	0.07	2.2	5		0.070	0.013	0.107	<
8	0.05	<0.22	<0.13	0.06	2.7	4		0.088	0.040	0.187	0.013
9								0.110	0.088	0.103	0.062
10										0.114	0.193
11								0.052	0.009	0.093	0.009
12								0.063	0.028	0.079	0.011

Horizon nr.	Horizon symbols	Depth cm	Mg^{++} (by $MgSO_4$ (compulsive method), cmol(+)/kg soil)	Na^+	K^+	Ca^{++}	Al^{+++}	Fe^{+++}	Mn^{++}	Free H^+	Lab nr.
1	OL	10-9									JM104
2	OF	9-3	1.22	0.20	0.59	7.71	1.18	0.16	0.116	9.12	JM105
3	OH	3-0	1.53	0.13	0.29	7.02	4.00	0.57	0.051	12.27	JM106
4	A/E	0-11/22	<0.12	<0.02	0.03	0.07	0.86	0.02	<0.002	0.73	JM107
5	Bh	11/22-30	<0.12	<0.02	0.03	0.12	5.34	0.04	<0.002	0.72	JM108
6a	Bhs										JM109
6	Bhs	30-39/45	<0.12	<0.02	0.03	<0.02	3.47	<0.01	<0.002	0.22	JM110
7	Bw	39/45-61/65	<0.12	<0.02	0.01	<0.02	1.08	<0.01	<0.002	0.07	JM111
8	C	61/65-86/103	<0.12	<0.02	0.02	<0.02	0.91	<0.01	<0.002	0.05	JM112
9	Cg1	86/103-91/104	<0.12	<0.02	0.03	<0.02	0.90	0.01	<0.002	<0.01	JM113
10	Cg2	91/104-105/117									JM114
11	Cr1	105/117-162									JM115
12	Cr2	162-...									JM116

Table 20 (continued): Analytical data for profile 602, Beerse, Province of Antwerp, Belgium. Profile studied 21/6/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
	cmol(+)/kg	cmol(+)/kg	%	cmol(+)/kg	cmol(+)/kg	Aqua Regia mg/kg					
1						850	4198	661	115	735	1643
2	20.3	<18	>100	10.6	10.7	466	1893	361	124	630	2512
3	25.9	25.3	36	16.9	17.1	381	1596	393	117	522	2272
4	1.7	<4	7	1.6	1.8	146	66	37	15	37	47
5	6.3	6.5	3	6.1	6.9	363	126	197	30	268	148
6a											
6	3.7	3.7	3	3.7	4.3	666	217	403	26	536	86
7	1.2	<4	10	1.2	1.2	759	262	488	31	102	37
8	1.0	<4	15	1.0	2.1	1135	264	752	33	61	47
9	0.9			0.9	1.1						
10											
11						1516	400	929	50	103	33
12						1481	414	1107	52	104	33

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	Aqua Regia mg/kg									dS/m 1:5	%
1	594	0.92	21.1	941	177	2	29.7	4.6	156		
2	1136	1.00	35.1	1615	48	3	67.7	7.3	133	0.12	
3	2287	1.45	158.4	4357	42	9	466.2	15.4	154	0.10	
4	913	0.08	3.1	296	6	3	4.5	0.7	7	0.02	
5	4727	0.26	1.5	751	8	7	4.6	1.3	11	0.04	
6a											
6	6567	0.11	0.9	1960	13	8	3.5	1.8	10	0.02	
7	5023	0.05	1.2	2437	17	10	2.3	2.5	11	0.01	
8	8019	0.08	1.1	4097	20	13	3.0	3.7	14	0.01	
9										0.01	
10										0.02	
11	8929	0.08	2.5	3997	30	16	3.8	4.5	15	0.03	
12	8512	0.08	3.0	4591	31	15	3.8	6.2	18	0.02	

The particle size distribution is dominated by sand. In the upper horizons the content of sand is 90-95%, dropping to 76-85% in the deeper subsoil. In the upper 8 horizons the distribution is very homogeneous between the different fractions. In H10-13 the content of clay and coarse silt is a bit higher. The content of fine and medium sand decreases with depth.

The soil contains nearly no nutrients beside what is stored in the litter layer, and the capacity to store nutrients is also very marginal again except for the litter layer. Removing the litter will result in a completely nutrition depleted soil. Instead of basic cations the CEC is storing aluminium to an extend that almost 95% of the cations are aluminium. This does not apply for the litter layer where aluminium only makes up 5.8% of the cations (table 22 and 23).

Although the content of dithionite and oxalate extractable iron and aluminium peaks in the Bh and the Bhs horizons the content is insufficient to qualify for a Spodic horizon. For a Spodic horizon to qualify on the presence of oxalate aluminium and iron the content of aluminium plus half of the content of iron should exceed 0.5%. The highest content with 0.25% is measured in H6.

The aqua regia extracted elements show the expected pattern, despite the content of lead in the OH horizon, which is 466 mg/kg, which is not an extremely high value but above the expected.

The bulk density is relatively low in H5 and H6 and increases in H7 and again in H8 (Table 21). This reflects the sandy nature and absence of any burrowing animals in depth. The water holding capacity for H4 and H7 is very low, which obviously is linked with the low content of clay and organic matter below the litter layer (Table 24 and Figure 27).

Table 22: Bulk density and water holding capacity for profile 505, Schilde

Horizon nr.	Horizon symbols	Depth cm	Actual water cont. %	BDs soil g/cm3	BDFE fine earth g/cm3	Lab nr.
1	OL	10-9	51			JM104
2	OF	9-3	81			JM105
3	OH	3-0	92			JM106
4	A/E	0-11/22	4	1.28	1.28	JM107
5	Bh	11/22-30	11			JM108
6a	Bhs		6	1.27	1.27	JM109
6	Bhs	30-39/45	6			JM110
7	Bw	39/45-61/65	3	1.51	1.51	JM111
8	C	61/65-86/103	9	1.64	1.64	JM112
9	Cg1	86/103-94/104	7			JM113
10	Cg2	91/104-105/117	16			JM114
11	Cr1	105/117-162	17			JM115
12	Cr2	162-...	17			JM116

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	------	------	------	Vol. % water	------	------	------	------
1								
2								
3								
4	48.0	42.9	31.9	21.3	8.9	6.0	3.5	0.7
5								
6a	54.3	52.4	44.3	32.2	20.1	16.7	11.6	8.9
6								
7	52.9	51.4	46.1	30.4	12.6	7.5	3.1	2.0
8	45.4	44.1	42.5	38.9	25.8	21.0	6.0	3.0
9								
10								
11								
12								

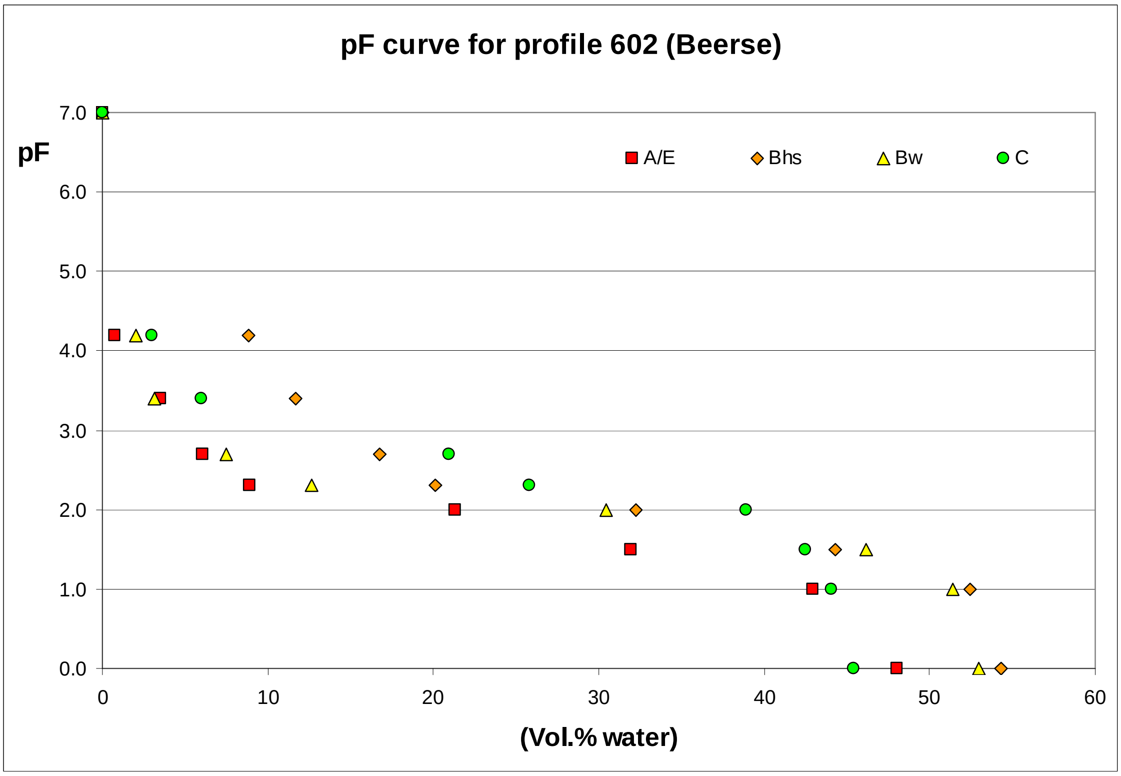

Figure 27: The pF values on water content for profile 602, Beerse. A steady decrease in water content with increasing pF values is observed. The subsoil horizons are able to store slightly more water than the surface horizons and the parent material.

10.3. Information deduced from the Belgian Soil Map

Soil profile 602 Beerse, is located on soil map 17W (Deckers, De Coninck and Tavernier, 1966). The area outlined by the soil map is characterised by a very complex soilscape. Most areas have texture symbol Z or S, with inclusions of sandy loam and clayey soils (Figure 28). The soil profile is located in an area mapped as Zcg and Zdg (Table 22). From the small water stream about 1000 m to the west of the soil profile, following soil sequence from wet to dry is observed: sEep (wettest), Sep, Zep, Zdg, Zcg (the soil profile), ZAg, X (driest).

Table 23: The map units present in the immediate surroundings of the soil profile 602, Beerse (after Baeyens and Tavernier, 1966).

Map symbol	Description
sEep	Poorly drained strong clayey gley soils with reduced conditions. Sand substratum starting at shallow depth (20-80 cm)
Sep	Poorly drained loamy sand soils. Alluvial soils lacking profile development.
Zep	Poorly drained sandy soils lacking profile development. Developed in fluvial sediments.
Zdg	Moderately well drained sandy soils with well developed humus and/or iron B horizon
Zcg	Well drained sandy soil with well developed humus and/or iron B horizon
ZAg	Excessively to somewhat excessively drained sandy soils with well developed humus and/or iron B horizons (soils with dune relief)
X	Inland dunes

Zcg: Well drained sandy soils with a well developed humus and/or iron B horizon. This soil type is characterised by a weak hydromorphic humus-iron Podzol. The typical horizon sequence is composed of a dark grey A horizon, a light grey E horizon, a black Bh and a yellow-brown Bs. Rust mottles start from 60-90 cm depth. This soil type is wet in winter and dry in summer. The quality of this soil for plant growth depends on the thickness of the humus rich topsoil (plaggen like or not). The studied soil profile is located within this map unit.

Zdg: Moderately well drained sandy soils with well developed humus and/or iron B horizon. The typical soil profile is described as a hydromorphic Podzol with a humus B horizon or with a humus-iron B horizon. The typical horizon sequence is Ap (the E horizon is only present as fragments in the Ap), Bh, Bs, BC.
The soil is described as rather wet in winter and spring, with water raising as high as 40 cm below the mineral surface. Drainage ditches are requested. This soil type is recommended as grassland and for agriculture.

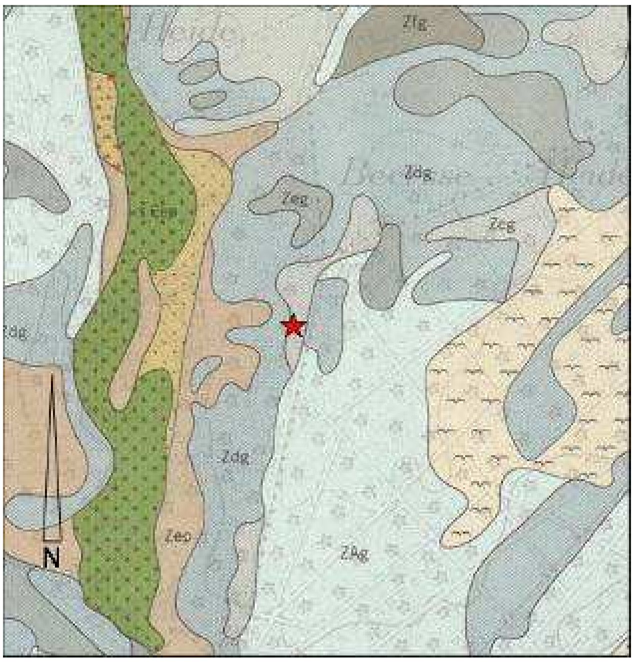

Figure 28: Detail of soil map Beerse 17W (Deckers, De Coninck and Tavernier, 1966). The location of the soil profile P602, Beerse is indicated with a red star.

The profile is located on a transition between extremely dry and poor sandy soils of the type inland dunes and ZAg and the more wet alluvial soils towards west.

The location of the farm close to the soil profile pit may be related to the spatial distribution of the soil types. The agricultural land of interest is the Zdg and wetter types, with the limitation that they have problems in winter being too wet. The farm is located just on the border to the Zcg soil type, which for agriculture is of little value. This soil type and the drier ones more to the east are indeed planted with coniferous forests.

10.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H4	Moist and dry colours are on the edge for an Albic horizon, but they are based on a composite sample of the A+E material making up the horizon. If a separate colour measurement had been made of the E part, an even more whitish colour would surely have been the result.
Cambic	-	The soil is too coarsely textured
Folic	H1-3	The OL, OF, OH horizons are together exactly 10 cm, which is sufficient to qualify.
Plaggic	-	Although spade marks or plough marks are present, the human impact on the soil is too weak
Spodic	H5	
Gleyic colour pattern	H10 H11-12	Oximorphic colours Reductomorphic colours
Reducing conditions	H11-12	

Simplified classification name
Albic Carbic Podzol • Carbic: H5 does not turn redder upon ignition

Full classification name without specifiers
Folic Albic Carbic Podzol (...) • Gleyic conditions are too deep to be included in the key (starts at 10 (the organic layer)+104 cm depth)

BioSoil classification name (WRB 2006), with specifiers
Hypofolic Albic Carbic Podzol (...) • Hypo is added to the Folic qualifier because it is just exactly thick enough (10 cm), and to make the thickness 1 cm of OL is included

10.5. Discussion

That this field has been planted with forest is very logic. Towards east and south-east the soilscape is dominated by land dunes and very dry sandy soils. Today these dunes are fossilised planted with pines as well. More towards the west the soils are wetter and better for agriculture.

The soil shows very clear spade marks into the Bh horizon, so in the past some kind of seed bed preparation has taken place. During this event the original A and E horizon became mixed, but considering the rather bleached colour of the mixed horizon as it appears today, most probably the original A horizon was very thin and the E horizon relatively thick and bleached. The soil is characterised by a very well outlined Bh and Bhs horizon. Below the Bhs horizon the soil has only undergone little pedogenesis. A bit of organic carbon has accumulated and some weathering has taken place with accumulation of iron. A groundwater table is responsible for the complete bleaching of H11-12. H10 is a thin zone of fluctuation with accumulation of iron in a mottled pattern, which is evidenced by the peak in dithionite iron.

The particle size distribution is typical for soils from the coversand of the Antwerp Kempen region. The very low nutrient holding capacity is a second major problem for this soil. The development of an Eumor is to be expected in such a physically and chemically poor soil.

The classification name according to World Reference Base (2006) is reflecting the morphological, chemical and physical characteristics and limitations of this soil.
The WRB-2006 soil classification name in this study correlates well with the FAO (1988) soil classification name of 'Haplic Podzols' given by the soil surveyors in 1993, although one might have overlooked the 'Carbic' properties in the first inventory.

11. Profile 703, Opglabbeek, Limburg

11.1. Site and profile description

Profile 703	**Opglabbeek (Level 1 forest plot)**
1.2 Date of description:	19/06/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Limburg, Opglabbeek Municipality. From the roundabout in the city centre of Opglabbeek take the road in western direction named “Weg naar Zwartberg”. After about 1850 m follow on the left the road Industrieweg Zuid (southern direction). After about 350 m, the road makes a left sharp turn of 90°. Park the car at the turn and continue by foot straight on along a bike trail. The experimental forest plot is located on the left (eastern) side of the bike trail within the forest delineated by the first and the second forest side road (Photo 29).
1.5 Profile coordinates:	*National plot nr.:* 703 *International plot nr.:* 4602 51° 01' 50.99" N; 5° 34' 02.86" E
1.6 Elevation:	85-87.5 m a.s.l.
2.1 Atmospheric climate and weather condition:	Partly cloudy, warm with temperatures exceeding 25°C and high humidity. In the days prior to the profile description it was very warm (25-33°C) and dry.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	The profile is located on a very gentle gravely alluvial fan, a fossil of a former Maas bed. About 500 m to the south of the experimental plot a very gentle valley allows water to drain towards the Bosbeek tributary (slope decline of 14 m within a distance of 2250 m). The Bosbeek runs from SSW to NNE for about 10 km before it drains into the Zuid Willemsvaart channel. Before this channel was constructed, the Bosbeek drained into the Maas river valley. The city of Opglabbeek has been founded on the important landscape divide between the Bosbeek tributary valley (wetlands) and the plateau (agricultural lands). The poor stony parent material is expressed in the high percentage of the landscape covered by forest or heath land in the nearby region, and in the many active gravel and sand quarries. The Maas river is located 14.5 km to the east of the forest plot. This river forms the country border with The Netherlands (Figure 29, 30 and 31).
2.4 Land-use:	Plantation forestry with selective felling. *Wildlife:* not protected *Grazing:* none, except by roe dears
2.5 Human influence:	Vegetation slightly disturbed. Forest is planted. A ditch system with a mutual distance of about 2 m is practically not visible anymore at the surface, but has an influence on the presence/absence of the E horizon.
2.6 Vegetation:	Coniferous forest

Tree layer		Shrub layer		Herb layer	
Scots Pine	*Pinus sylvestris*			Black Cherry	*Prunus serotina*
Mountain Ash	*Sorbus aucuparia*			Bilberry	*Vaccinium myrti*
Pedunculate Oak	*Quercus robur*			Brambles	*Rubus sp.*
				Mountain Ash	*Sorbus aucupar*
				Purple Moor Grass	*Molinia caerulea*
				Narrow Buckler Fern	*Dryopteris carth*

2.7 Parent material:	River terrace sand or gravel (5310)
2.8 Drainage class:	Somewhat excessively drained *Availability of water:* sufficient
2.9 Internal drainage:	Never saturated
2.10 External drainage:	Neither receiving nor shedding water
2.12 Groundwater:	Extremely deep, >2 m
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None, except where brought to the surface by humans (roads, ditches…) or by animals digging in the ground. Stones are present from just below the forest floor.
2.15 Erosion, sedimentation:	No evidence of erosion
Humus classification:	Horizon sequence found: OL, OFz, OHnoz, Ae (photo 31) OH, with abrupt boundary to the Ae mineral soil. Ants observed, but no evidences of earthworms *Classification name:* Hemimor
Remarks:	No reaction of the matrix to α,α-dipyridyl, nor reaction to H_2O_2. Texture class by pipette method except for H5

No.		**Horizon description:** (see also photo 32)
H1-2	OL/ OFz	-10 till -5 cm; OF: dark brown 7,5YR 3/2 (M); mostly dead and living mosses, oak leaves and dead wood; no stones; few very fine and fine roots; clear, smooth boundary
H3	OHnoz	-5-0 cm; very dark brown 7.5YR 2.5/2.5 (M); decomposed and strongly fragmented OM; no stones; many very fine to coarse roots; abrupt, smooth boundary
H4	A+E/Ae	0-7/10 cm; locally divided into A and E horizons (see H5); black 10YR 1/1 (M), very dark grey 10YR 3/1 (D); loamy sand; coarse fragments: many (42% by weight), fine gravels to stones (<10 cm dia.), mostly sub rounded less common sub angular and broken, fresh to slightly weathered, mixed mineralogy (quartzitic, metamorphic, sedimentary, few iron concretions…); single grain; loose; moderate porosity; common very fine to fine and very few medium roots; clear, smooth boundary
H5	E	[8-18 cm, pocket of original E horizon present on corner of back and right wall, see photo 33)]; brown 10YR 4/2 (M), grey 10YR 6/1 (D); sand (by finger test); coarse fragments: many (36% by weight) fine gravel to stones (<10 cm), sub rounded, few sub angular, fresh, mixed mineralogy (quartzitic, metamorphic, sedimentary rock fragments); loose; low porosity; clear, broken boundary
H6	Bh	7/10-11/14 cm; black 10YR 2/1 (M), dark grey 10YR 4/1 (D), 7.5Y R6/4 (colour after ignition); loamy sand; coarse fragments: many (35% by weight) fine to coarse gravel, sub-rounded, sub-angular, few angular and flat, fresh, mixed mineralogy; very friable; low porosity; common very fine to fine and very few medium roots; clear, smooth boundary
H7	Bhs	11/14-21 cm; dark brown 7.5YR 3/3 (M), dark greyish brown 10YR 4/2 (D), 5YR 6/4 (colour after ignition); loamy sand; abundant (44% by weight), fresh, fine to coarse gravels, medium and coarse gravel mostly sub-rounded, fine gravel mostly angular and sub-angular, mixed mineralogy (quartzitic, metamorphic, sedimentary rock fragments); single grain; loose; few very fine and fine roots; clear, smooth boundary

H8	Bs	21-33 cm; brown to yellowish brown 10YR 5/3.5 (W), yellowish brown 10YR 5/5 (M), yellowish brown to light olive brown 1.5Y 5/4 (MC), light yellowish brown to brownish yellow 10YR 6/5 (D); loamy sand; many (38% by weight), sub-angular and sub-rounded, fresh to slightly weathered, mixed mineralogy, fine to coarse gravels; single grain; loose; very few very fine roots; clear, smooth boundary
H9	B1	33-38/51 cm; light yellowish brown to light olive brown 2.5Y 5.5/4 (M), light yellowish brown 2.5Y 6/3 (D); loamy sand; abundant (47% by weight), sub-angular and sub-rounded, fresh, mixed mineralogy, fine to coarse gravels, soil capping on larger gravels; single grain; loose; few very fine roots; abrupt, broken boundary
H10	B2	38/51-52 cm; dark yellowish brown 10YR 4/5 (M), yellowish brown 10YR 5/5 (D); sandy loam; abundant (42% by weight), angular, sub-angular and sub-rounded, fresh to slightly weathered, mixed mineralogy, fine to coarse gravels, most medium and coarse gravels are partly covered by coating of fine earth material with iron as cementing agent in form of cappings, bottom part of gravels are clean; single grain; very friable; very few very fine roots; clear, broken boundary
H11	BC	52-75 cm; dark yellowish brown 10YR 4/6 (M), yellowish brown 10YR 5/7 (D); very few, medium, prominent, clear, oxido-reduction pale olive to pale yellow 5Y 6.5/3 (M) mottles; sandy loam; abundant (41% by weight), sub-rounded to sub-angular, fresh to slightly weathered, mixed mineralogy, fine to coarse gravels, most medium to coarse gravel have soil cappings and clean bottom parts, some gravels with blackish Mn stains; single grain; very friable; very few very fine roots, to a depth of 65 cm; gradual, smooth boundary
H12	C	75-110 cm; dark yellowish brown 10YR 4/5 (M), yellowish brown 10YR 5/6 (D); loamy sand; abundant (49% by weight), sub-rounded, sub-angular and angular, fresh, mixed mineralogy, fine gravel to stones, larger fragments have soil cappings and clean bottom parts, common blackish Mn stains on surface of stones; massive; loose; no roots

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Photo 29: Image illustrating the edge of the forest plot hosting profile 703 (Photo JM)

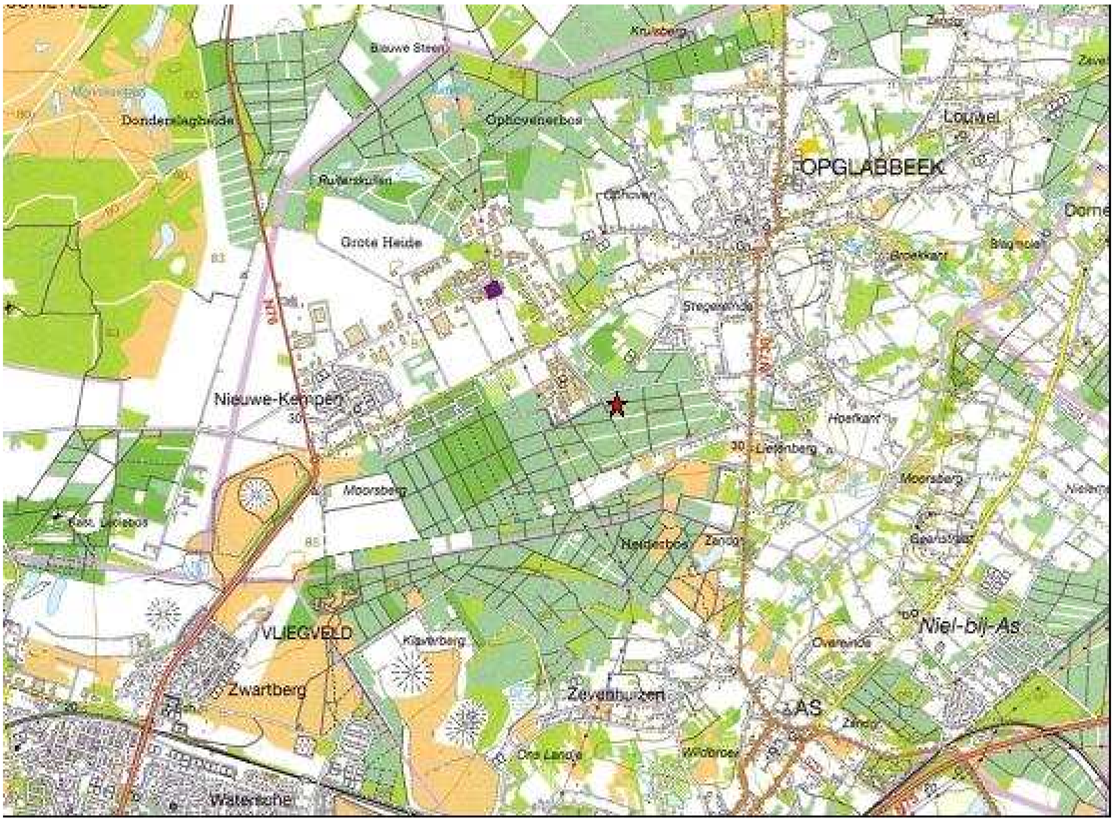

Figure 29: Topographical map of the area around Opglabbeek. The distance from west to east is 9000 m (NGI, 2002, map 86)

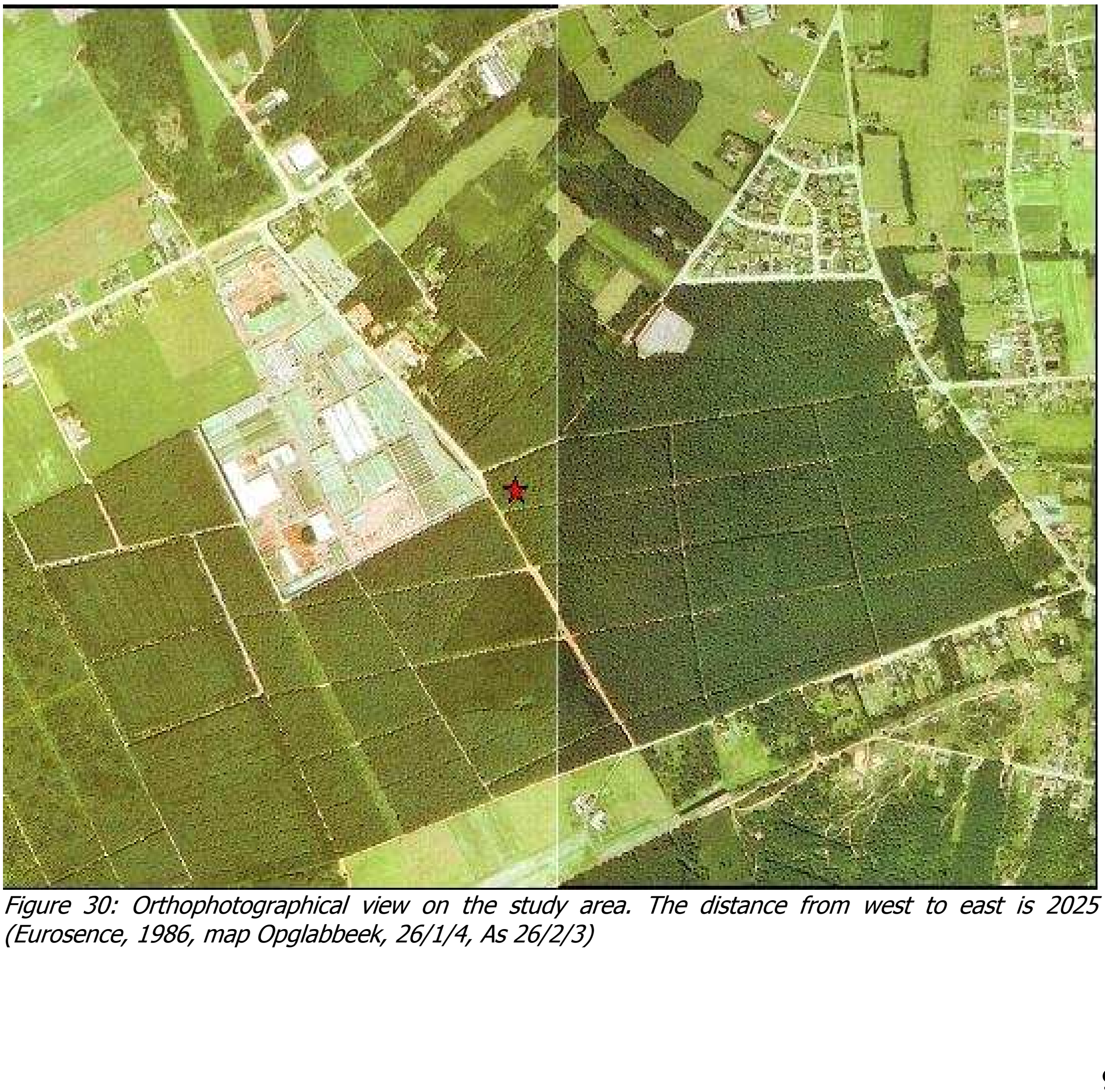

Figure 30: Orthophotographical view on the study area. The distance from west to east is 2025 m (Eurosence, 1986, map Opglabbeek, 26/1/4, As 26/2/3)

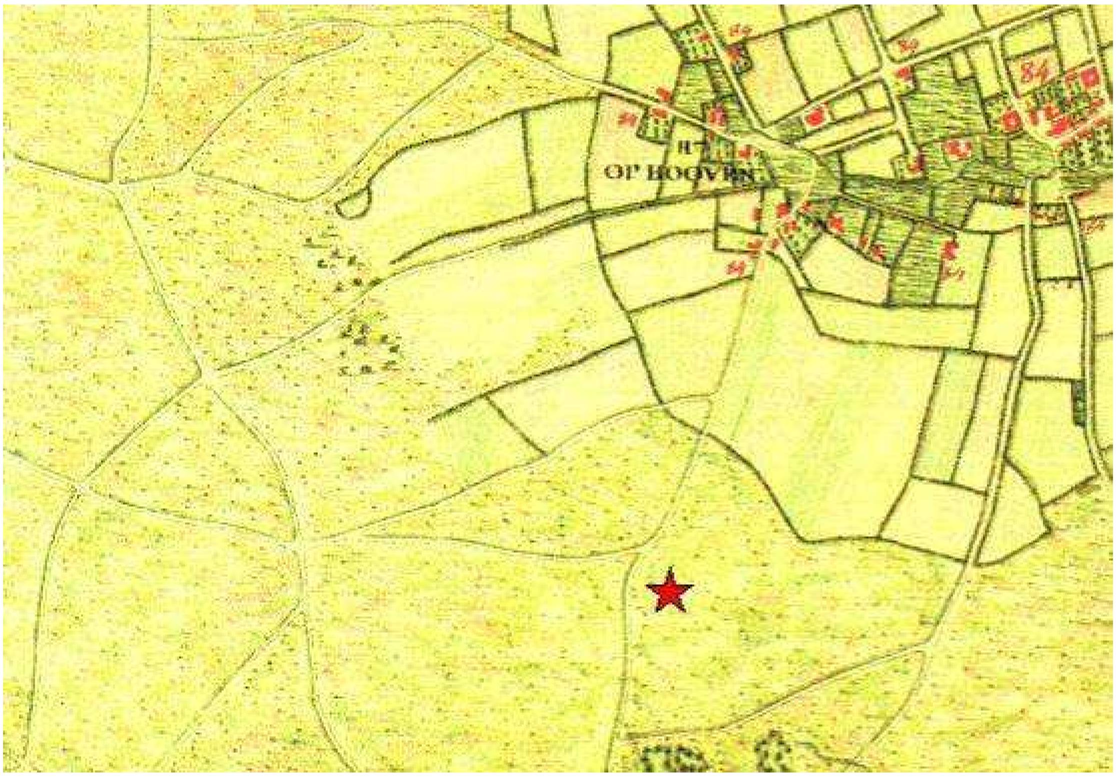
Figure 31: Cut out of the Ferraris map of Opglabbeek (Ferraris, 1777, map nr. 187/1) Distance from west to east is 3200 m.


Photo 30: Profile 703 with the vegetation in the immediate surroundings (Photo JM)

Photo 31: Close up of profile 703 with the forest floor and the upper mineral horizons visible (Photo JM)

Photo 32: View on the back side of profile 703. At this level the eluvial horizon (H3b) is well developed (Photo by JM)

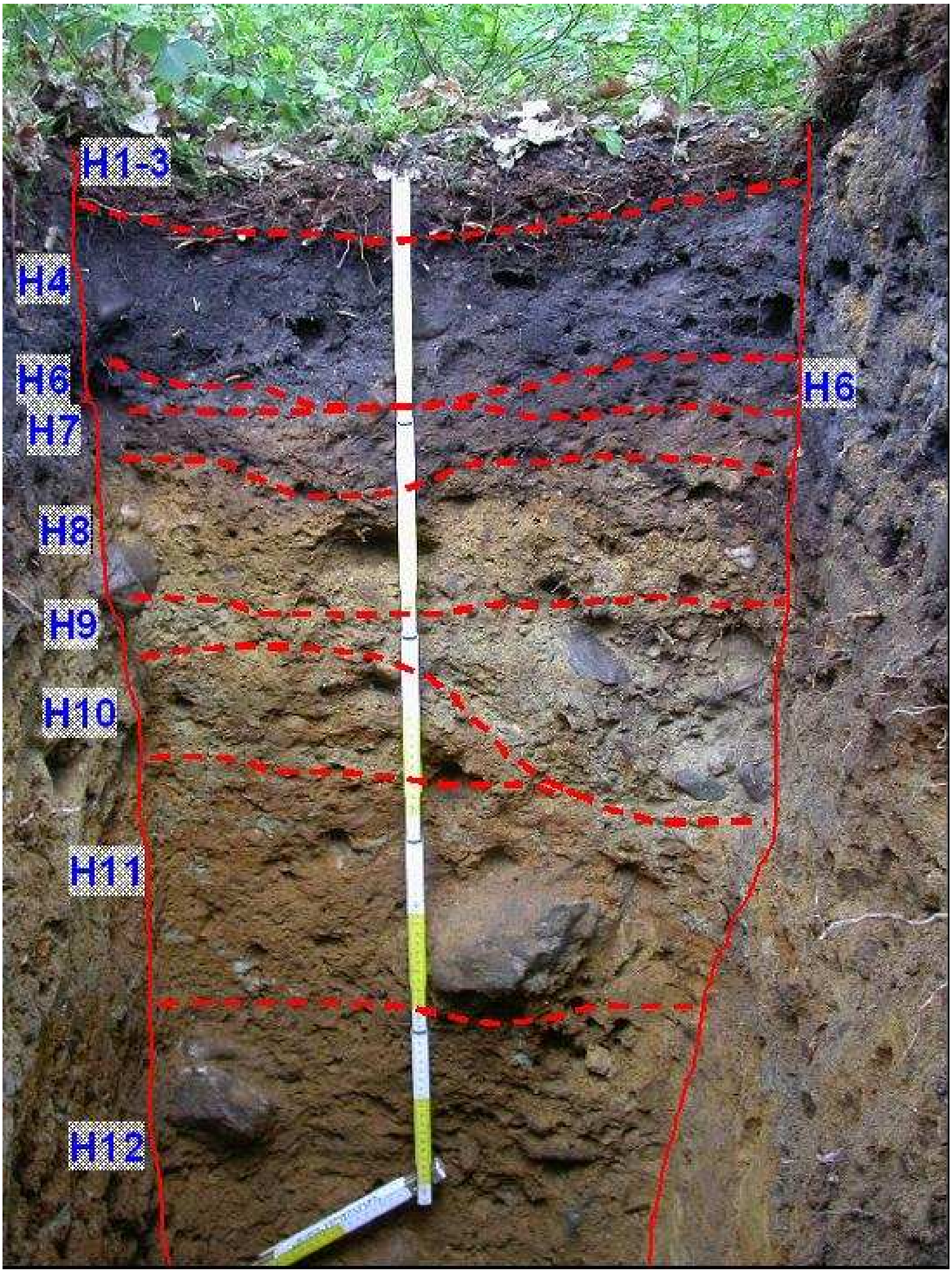

Photo 33:Soil profile 703. This profile is the most stony one among the 10 level I profiles studied in the frame of BioSoil.

11.2. Analytical data

The C/N ratio is high for most analysed horizons, so high that earthworms will be absent in this soil. A peak of 2.7% organic carbon is observed in the Bh horizon. The pH is fluctuating around 4 in the upper part of the soil and increases to about 4.5 in the lower part (Table 23).
A rather high content of stones is characterising all horizons of this soil. The stones were clearly observed during digging of the profile, which had to be done with the help of a pick axe. Soil cappings on the larger stones was observed in several horizons (see the profile description). The contents of stones are weight based, and analysed in the laboratory and are based on samples of several kilos each. In principle volume based values on the stone content should be lower than the weight based ones, as stones in lack of porosity will have a higher weight per volume unit if the packing spaces are filled with finer material.

Table 24: Analytical data for profile 703, Opglabbeek, Limburg, Belgium. Profile studied 19/6/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth (cm)	Total N (Kjeldahl) Modified (%)	Total N Standard (%)	Org. Carbon TOC (%)	Org. Carbon W&B (%)	OM LOI (%)	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm (%-wght)
1	OL	10-9									
2	OF	9-5	1.583				93		4.3	3.5	
3	OH	5-0	1.763				91		3.6	2.7	
4	A/E	0-7/10	0.301	0.315	7.34	6.9		3.1	3.6	3.1	42
5	E	[8-18]	0.028	0.035	0.44	0.4		3.5	4.0	3.7	36
6	Bh	7/10-11/14	0.113	0.121	2.72	2.5		3.4	3.9	3.4	35
7	Bhs	11/14-21	0.070	0.090	1.40	1.5		3.5	4.0	3.6	44
8	Bs	21-33	0.060	0.052	0.61	0.6		3.9	4.7	4.4	38
9	B1	33-38/51			0.25	0.3		4.0	4.9	4.6	47
10	B2	38/51-52			0.26	0.2		3.9	4.8	4.3	42
11	BC	52-75			0.09	<0.1		3.8	4.9	4.3	41
12	C	75-110			0.06	<0.1		3.8	4.9	4.3	49
Horizon nr.	**Particle size distribution (fractions in µm), %: 0-2**	**2-10**	**10-20**	**20-50**	**50-63**	**63-100**	**100-125**	**125-250**	**250-500**	**500-1000**	**1000-2000**
1											
2											
3											
4	2.8	3.3	2.5	10.1	0.8	7.9	8.5	33.9	16.1	6.2	7.6
5											
6	2.4	3.6	1.9	9.5	1.1	9.6	11.4	37.4	14.3	5.2	3.3
7	2.3	2.9	2.7	9.4	1.2	10.7	12.6	35.9	13.9	4.0	4.0
8	3.2	2.1	1.6	8.0	1.0	7.7	9.9	35.7	16.6	5.6	8.6
9	3.4	0.6	1.6	7.7	1.0	9.1	11.6	34.9	14.2	5.2	10.6
10	8.8	1.3	1.7	9.1	1.1	8.1	9.2	30.2	12.8	6.5	11.2
11	10.2	0.8	0.7	7.5	1.2	10.6	10.2	32.6	13.2	5.9	7.0
12	7.2	0.3	0.8	5.1	0.8	7.9	8.1	29.0	16.6	10.6	13.4
Horizon nr.	**Mg++ (by NH_4OAc, cmol(+)/kg soil)**	**Na+**	**K+**	**Ca++**	**CEC**	**BS (%)**	**CEC/clay**	**Al Dithi. Citrate (%)**	**Fe Dithi. Citrate (%)**	**Al Oxalate (%)**	**Fe Oxalate (%)**
1											
2	1.83	0.24	1.85	13.79	61.8	29				0.029	0.053
3	0.91	0.20	0.96	6.38	91.3	9				0.084	0.115
4	0.23	0.03	0.15	0.24	17.8	4		0.058	0.281	0.070	0.252
5								0.006	0.057	0.009	0.036
6	0.17	0.02	0.05	0.09	10.0	3	26	0.079	0.604	0.056	0.403
7	0.19	0.02	0.04	0.05	6.1	5	58	0.085	0.501	0.063	0.278
8	0.14	0.02	0.04	0.02	2.9	8	24	0.100	0.208	0.100	0.080
9	0.14	0.02	0.04	0.02	2.2	10	39				
10											
11	0.15	0.02	0.12	0.03	5.0	6	46	0.081	0.325	0.055	0.063
12	0.14	0.02	0.11	0.02	4.2	7	54	0.051	0.305	0.078	0.089
Horizon nr.	**Horizon symbols**	**Depth (cm)**	**Mg++ (by $MgSO_4$ (compulsive method), cmol(+)/kg soil)**	**Na+**	**K+**	**Ca++**	**Al+++**	**Fe+++**	**Mn++**	**Free H+**	**Lab nr.**
1	OL	10-9									JM117
2	OF	9-5	2.15	<0.1	1.72	17.11	<0.19	<0.03	1.698	4.57	JM118
3	OH	5-0	1.04	<0.09	0.94	8.51	3.50	0.33	0.261	10.70	JM119
4	A/E	0-7/10	<0.24	<0.04	0.15	0.16	3.67	0.35	0.024	2.03	JM120
5	E	[8-18]									JM121
6	Bh	7/10-11/14	<0.12	<0.02	0.05	0.05	2.24	0.31	<0.002	0.88	JM122
7	Bhs	11/14-21	<0.12	<0.02	0.04	<0.02	2.27	0.15	<0.002	0.47	JM123
8	Bs	21-33	<0.12	<0.02	0.02	<0.02	1.06	0.01	<0.002	0.06	JM124
9	B1	33-38/51	<0.12	<0.02	0.02	<0.02	0.63	<0.01	<0.002	0.03	JM125
10	B2	38/51-52									JM126
11	BC	52-75	<0.12	<0.02	0.09	<0.02	3.01	<0.01	0.010	0.08	JM127
12	C	75-110	<0.12	<0.02	0.09	<0.02	2.81	<0.01	0.009	0.10	JM128

Table 23 (continued): Analytical data for profile 703, Opglabbeek, Limburg, Belgium. Profile studied 19/6/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
	cmol(+)/kg	cmol(+)/kg	%	cmol(+)/kg	cmol(+)/kg	Aqua Regia mg/kg					
1						3411	6743	1021	135	944	1607
2	27.3	30.3	69	6.3	5.1	1005	3923	481	84	711	1950
3	25.3	31.1	34	14.8	12.1	657	2200	320	182	657	2602
4	6.4	8.3	5	6.1	7.8	806	269	324	92	291	601
5											
6	3.5	4.1	4	3.4	4.2	507	197	164	52	121	186
7	2.9	<4	6	2.9	3.6	569	201	208	56	108	146
8	1.2	<4	5	1.1	1.2	999	256	478	87	100	126
9	0.7	<3	7	0.7	0.8	1055	297	558	84	50	65
10											
11	3.2	3.5	5	3.1	3.1	3391	208	1845	73	186	116
12	3.0	<4	9	2.9	2.6	3299	329	1827	79	244	139

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC dS/m 1:5	$CaCO_3$ %
	Aqua Regia mg/kg										
1	1538	0.89	13.5	2206	807	6	11.4	5.1	110		
2	1078	0.89	15.1	1645	587	6	23.4	6.7	101	0.07	
3	1886	1.04	19.5	2865	104	8	98.8	11.8	101	0.17	
4	5420	0.36	15.4	10901	97	16	98.4	7.3	44	0.07	
5										0.01	
6	3264	0.19	5.0	9572	31	11	27.4	1.4	19	0.03	
7	4323	0.14	2.2	9896	29	10	6.6	1.3	12	0.03	
8	8665	0.07	1.4	9673	48	15	6.0	4.3	18	0.02	
9	8219	0.04	1.2	3561	36	13	3.5	5.2	16	0.02	
10										0.02	
11	13908	0.16	6.1	23711	199	31	8.7	8.8	29	0.02	
12	12821	0.24	6.8	28837	460	36	12.3	9.8	30	0.02	

The particle size distribution through the soil shows only a few heterogeneities such as the higher clay content in H10-12. This is furthermore the only soil among the 10 soils described in this report with a considerable amount of coarse and very coarse sand. This is clearly linked with the high coarse fragment content.

The content of basic cations is low as it could be expected from a soil dominated by sand in the fine earth fraction and with an important coarse fraction making up the total soil volume. What should be noticed is that the higher content of clay in the subsoil by no means has resulted in a higher content of basic cations nor in a higher CEC. The CEC of the clay shows a general increasing trend with depth indicating that the clay minerals are less weathered in the deeper horizons. The presence of aluminium as a cation increases with depth from 57% in the Ap horizon to 94% in the BC horizon. In the OH horizon the aluminium saturation is only 14%, which is by no means a toxic level for plant uptake. For the mineral horizon on the other hand the very high saturation by aluminium is a considerable problem as aluminium due to its small size and large positive charge (Al^{+3}) is very strongly adhering to the cation exchange complexes and can only with difficulty be exchanged by more valuable cations such as potassium, calcium or magnesium.

The dithionite extractable iron shows two peaks, one in the deeper subsoil (H11) and a higher one in the Bh horizon, where 0.6% was measured. The oxalate extractable iron peaks in H6 as well and shows no second peak in the deeper subsoil. The content of dithionite and oxalate extractable aluminium have only one peak and that is in the Bs horizon. The pattern on presence of iron and aluminium oxides fits well with the horizons most under influence of podzolisation.

The data on aqua regia shows no deviating pattern, although the content of iron in the deepest subsoil is rather high. As the peak is not found in the data on dithionite extractable iron, the peak must be related to iron present in the clays or other minerals, such as glauconite. Due to the stony nature of this soil no bulk density rings could be taken. Instead the excavation method was applied on a 50 by 50 cm horizontal squared surface. For each depth the entire soil volume was excavated and analysed in the laboratory, applying several sized sieves.

The bulk density appears irregular with values ranging between 1.1 and 1.8 g/cm^3 if the stones are included, and between 0.75 and 1.3 g/cm^3 when the stones are excluded (Table 24).

Another interesting aspect is that the coarse fraction particular is concentrated in the depth from 5 to 10 cm (measured from the contact between the forest floor and the mineral soil). In this layer the stoniness is 58% by weight, mostly present as very fine gravel in the fraction 2-3.15 mm. In general most coarse material is larger than 4.75 mm and the fraction larger than 10 mm is still well represented with minimum 10% through the analysed depth.

Table 25: Gravels and bulk density according to fixed depths

Depth*	<2 mm	2-3.15 mm	3.15-4.75 mm	4.75-10 mm	>10 mm	BD soil	BD fine earth
cm	----------------------------		Weight %		----------------------------	g/cm3	g/cm3
0-5	72	3	4	11	10	1.31	1.11
5-10	42	27	4	13	14	1.83	1.29
10-20	56	5	6	16	17	1.09	0.75
20-40	61	7	5	15	12	1.45	1.12
40-60	69	7	4	10	10	1.51	1.27

* Depth measured from the mineral soil surface

11.3. Information deduced from the Belgian Soil Map

The soil profile is located on map unit Zbgt (Figure 32). The definition of Zbgt is: soils with a sandy texture class, no gley, good drainage, Podzols with a clear formation of an E horizon resting on top of a humus and/or iron B horizon. The "t" is added for soils with presence of gravel in the parent material.

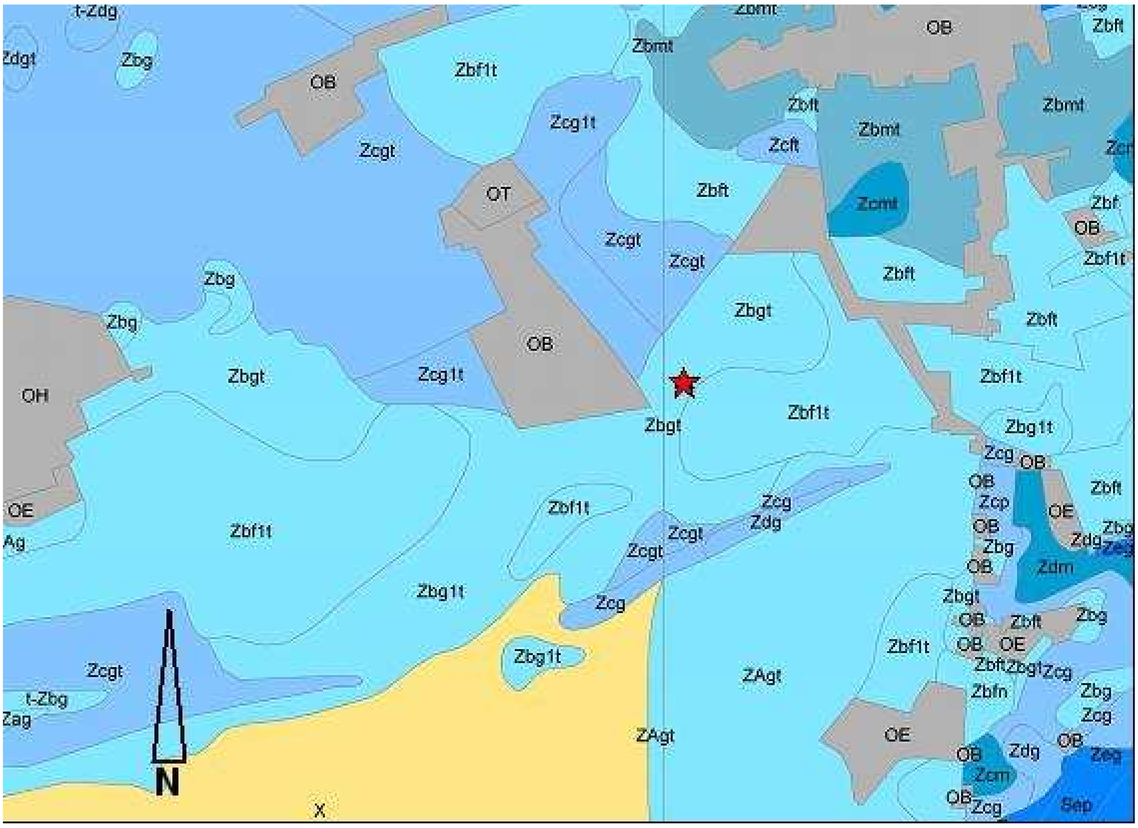

Figure 32: Detail of the digital soil map of Gestel 63W. Profile 703 is located on map unit Zbgt

11.4. Classification according to World Reference Base (2006)

Just by looking at the photo of this soil two things are obvious. The one is the stony nature, the other is the Podzolic colours. To key out in the World Reference Base (2006) in the reference soil group Podzols, a Spodic horizon is diagnostic. Simplified two types of Spodic horizons are qualifying. The one type is defined on its colour alone if directly underlying an Albic horizon, the other type requires no presence of an Albic but something more like cementation of the Spodic, sufficient high content of oxalate extractable Al and Fe, cracked coatings on sand grains etc. Profile P703 is an example of a soil that has been exposed to shallow ploughing for a few times. Due to this cultivation the A and E horizons have been mixed. Despite of the ploughing the original E horizon is preserved, but only where it has developed deeper than the plough depth. The Spodic horizon is not cemented, the presence of cracked coatings on sand grains was not tested in the field, nor by micromorphology. The oxalate extractable Al and Fe content is too low and Fe lamellae are not present in the soil. When classifying this soil the presence/absence of an Albic horizon is essential, because only where present the Spodic horizon is surely present as well. For BioSoil it is assumed that the Spodic horizon will qualify independent on the presence of an Albic, as an example because of the presence of cracked coatings.

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H5	Broken horizon- present only in pockets. The discontinuous presence is due to the construction of drainage ditches, whereby the upper horizons were destroyed or mixed. Are pockets of Albic horizons qualifying? No. If important changes (e.g. different SRG's) are observed within a soil profile then both pedons should be classified separately and reported as such.
Argic	H10-11	No evidences of clay coatings
Folic	H1-3	The horizon is exactly 10 cm thick, a small compaction of the OL and the Folic is too thin. Seasonal variation on the presence/absence of a Folic horizon is most likely.
Spodic	H6-7	H7: colours measured in field 7.5YR3/3, in lab. 10YR3/2! H6: colours ok. If H5 is recognised as an Albic horizon no further evidences are required. Where no Albic horizon is present we have to check for other evidences for a Spodic horizon. According to Dr. Otto Spaargaren, H7 will qualify for requirement 3.b.ii: "cracked coatings on sand grains covering 10% or more of the surface of the horizon". The best way to confirm the presence of cracked coatings is by studying impregnated soil slices under a microscope (micromorphology), a technique that is beyond the scope of BioSoil.

Simplified classification name
Albic Rustic Podzol • Rustic: colours after ignition are for H6 7.5YR6/4 and for H7 5YR6/4

Full classification name without specifiers
Folic Albic Rustic Podzol (Skeletic)

BioSoil classification name (WRB 2006), with specifiers
Hypofolic Albic Rustic Podzol (Skeletic)

If the Spodic horizon is not qualifying except where overlain by an Albic horizon, the soil will not key out as a Podzol. The second most important diagnostic horizon, properties or material present in this soil is the Argic horizon, which has developed in H10-11, although its illuvial nature has not been documented. In absence of a lithological discontinuity the Argic horizon is accepted. As the base saturation is very low and is never above 50% and as the CEC of the clay exceeds 24 cmol/kg clay the soil keys out in Alisols. No prefix qualifiers are present, and of the suffix qualifiers the Alumic, Humic, Hyperdystric, Skeletic and Arenic are present.

Advanced classification name (WRB 2006):
The soilscape in the surroundings of the international Level I Forest Plot number 703, is composed of two major soil types, these are the: **Hypofolic Albic Rustic Podzol (Skeletic)**, where an Albic horizon is present, and **Haplic Alisol (Alumic, Humic, Hyperdystric, Skeletic, Arenic)**

11.5. Discussion

Profile 703 has one eye catching characteristic and that is the – for Flanders relatively - high content of coarse fragments. Another characteristic is the strong colouring of the different horizons in accordance with what can be expected for a Podzol soil (dark brown Bh, orange brown Bs etc.). Not only has the soil high content of coarse fragments, it also has a relatively high content of coarse and very coarse sand. If it was not for the clay content, which is about 10% from about 50 cm depth, this soil would have a serious water deficit shortly after any rain period.

Due to construction of drainage ditches the eluvial horizon has been destroyed in part of the soilscape. To express this pattern of a soilscape with or without an Albic horizon, two classification names has been proposed. This dual name in function of the presence/absence of an Albic horizon illustrates some classification problems:

1) Where the soil is classified as a Podzol, the Alic horizon present in the subsoil is not included in the classification name.
2) Where the soil is classified as an Alisol, the presence of a Podzolic destroyed topsoil is ignored.
3) The Folic horizon is not listed among the qualifiers for Alisols

A conceptual problem illustrated by this soil profile, is to what extent the classification name on the Reference Soil Group level can or should be changed just because it was a common practice in Flemish forests to plough the plot before a new forest was planted. Consulting all information available in the profile description and the laboratory data, this soil belongs rather among the Podzols than among Alisols. The illuvial character of the Alic horizon is also questioned, though according to the diagnostic criteria it is an Argic horizon, morphologically it should not key out in this group. A more appropriate reference soil group would be a landscape of preserved Podzols and Arenosols, where the Spodic horizon either is destroyed or too immature to qualify.

The WRB-2006 soil classification name in this study correlates quite well with the FAO (1988) soil classification name of 'Haplic Podzols' given by the soil surveyors in 1993.

12. Profile 801, Wimmertingen, Limburg

12.1. Site and profile description

Profile 801	**Wimmertingen (Level 1 forest plot)**
1.2 Date of description:	12/5/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Limburg, Wimmertingen Municipality. Along high-way E313 take exit 28 (Hasselt) in southern direction along Huiserveldstraat (N80). After about 2000 m turn left along Steenberg and then after 800 m turn right in southern direction. After 500 m a small bridge leads over the Mombeek tributary. Immediately after the bridge follow for 200 m the field road on the left hand side in eastern direction. Just before the road turns in northern direction, the Level 1 forest plot is located in the tributary valley between the Mombeek tributary (parallel with the field road) and the drainage channel more to the south (at the transition between the slope and the valley).
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 57 *Code profile:* 801 *Latitude, longitude:* 50° 53' 14.56" N, 5° 19' 35.11" E
1.6 Elevation	30-35 m a.s.l.
2.1 Atmospheric climate and weather condition:	In the days prior to the field work the weather was sunny and relatively warm (20-25°C in day time). During the fieldwork it was sunny in the morning and slightly overcast in the afternoon. The temperature was about 23°C.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The landscape of the region is gently rolling, except immediately to the north of the tributary of the level 1 plot. Here the landscape is much more rolling and the altitudes markedly higher (Figure 33 and 34). *Meso topography:* The profile is located at the bottom of a relatively flat tributary valley. A drainage channel has been constructed about 30 m to the south of the profile, at the north side the water stream is running. This drainage channel keeps the groundwater table artificially low. The tributary is running from east to west, the slopes towards the tributary are north and south facing. *Landscape position:* Bottom in gently undulating landscape *Slope form:* - *Slope gradient:* - *Slope length:* To the north the general slope is about 1000 m long with maximum altitude difference of 65 m. To the south the slope is also about 1000 m long with altitude around 45 m, before dipping down towards the next tributary valley. *Slope orientation:* The tributary is running from east to west.
2.4 Land-use:	Plantation forestry. *Wildlife:* no evidences of hunting. *Grazing:* no.
2.5 Human influence:	Vegetation strongly disturbed. The forest is composed of mono-cultured poplar. The forest floor is strongly disturbed by heavy machinery, especially towards the drainage channel. Tracks are the result of machinery driving over the land while it was too wet. A few meters to the east and about 50 m to the west of the profile

	are zones of clear cuts, with planting of new poplar (photo 34).
2.6 Vegetation:	Deciduous woodland with no shrub layer (photo 35).

Tree layer		**Shrub layer**		**Herb layer**	
Poplar	*Populus sp*			Stinging nettle	*Urtica dioica*
				Cleavers	*Galium aparine*
				Lesser celandine	*Ranunculus ficaria*

2.7 Parent material:	River clay and silt (5410)
2.8 Drainage class:	Poorly drained *Availability of water:* excessive
2.9 Internal drainage:	Saturated for long periods every year, especially in winter and early spring.
2.10 External drainage:	Ponded
2.12 Groundwater:	Moderately deep (reduced from 54 cm depth). GWT at 65 cm at the day of profile description.
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	No evidences of erosion
2.17 Surface cracks:	Surface polygonal cracks are present from the surface and extends down to a depth of 15-20 cm (H3). They are very wide (4-8 cm) and the diameter of the polygons are about 10-15 cm. The cracks are filled with earthworm casts and granules. The cracks are probably the result of surface desiccation during the summer months.
Humus classification:	The soil has a discontinuous OLn horizon overlying an Az mineral horizon with a granular structure and many earthworm galleries (photo 36). *Classification name:* Mull → subdivision: Eumull
Remarks:	No stones, nor nodules or cementation through the profile. The rooting depth below an uprooted tree is deeper than the soil profile. In H2 the roots mainly originates from the ground vegetation; below this horizon the majority are tree roots. The largest roots of the uprooted tree (1-10 cm diameter) are mostly horizontal oriented, those with a diameter less than 1 cm are mostly vertical oriented.

No.		**Horizon description** (see also photo 37)
H1	OLn	-1-0 cm; litter layer, discontinuous; clear irregular boundary
H2	A	0-5/20 cm; very dark greyish brown 10YR 3/2 (M), very dark greyish brown to dark greyish brown 10YR 3.5/2 (D); no mottles; positive reaction to ɑ,ɑ-dipyridyl; clay; granular; friable; throughout; faint humus+clay coatings in open bio galleries; very high porosity; strong reaction to H_2O_2; many very fine and very few fine to coarse roots; many earthworms observed while digging the profile, insect eggs; abrupt irregular boundary
H3	Btg1	5/20-26 cm; dark greyish brown 2.5Y 4/2 (M), greyish brown 2.5Y 5/2 (D); common medium distinct, diffuse mottles, 7.5YR 3/3 (M); positive reaction to ɑ,ɑ-dipyridyl; clay; very coarse, well developed, angular blocky, common shiny pressure faces; firm; faint, many to abundant shiny clay+humus coatings in macro pores and on ped and fracture faces; high porosity; very few, nodular, <2mm, rounded, hard, iron/manganese oxide, reddish brown nodules; strong reaction to H_2O_2; very few very fine to medium and few coarse roots; clear smooth boundary
H4	B(t)g2	26-37 cm; reduced part: light olive brown 2.5Y 5/3 (M), light yellowish brown 2.5Y 6/3 (D); abundant (40-50%), coarse, prominent, diffuse mottles, 10YR 4/4 (M), 10YR 4/3 (MC); reduction along pores, more oxidised in-peds; positive reaction to ɑ,ɑ-dipyridyl; clay; coarse, well developed, angular blocky, shiny pressure faces; friable; thin humic coatings on some pores and very few humus+clay coatings in macro pores; high porosity; strong reaction to H_2O_2; very few very fine to medium and few coarse roots; clear smooth boundary
H5	BCg	37-47 cm; reduced part: light olive brown 2.5Y 5/3 (M), strong brown 7.5YR 4/6 (MC), yellowish brown 10YR 5/4 (D); abundant (80-90%), coarse, prominent,

		diffuse mottles 7.5YR 4/5 (M); reduction along macro and meso pores; strong positive reaction to α,α-dipyridyl; clay; massive; friable; high porosity; no reaction to H_2O_2; clear smooth boundary
H6	Cg	47-54 cm; matrix composed of coarse, prominent, diffuse greenish grey 5GY 6/1, dark yellowish brown 10YR 4/4 and light olive brown 2.5Y 5/3 mottles; positive reaction to α,α-dipyridyl; clay; massive; friable; moderate porosity; no reaction to H_2O_2; common very fine to medium and few coarse roots; abrupt smooth boundary
H7	Cr	54-… cm; dark greyish brown 10YR 4/2 (M), brown 10YR 5/3 (D); common (5-10%), medium, distinct, diffuse rusty mottles; strong positive reaction to α,α-dipyridyl; clay; massive; friable; no reaction to H_2O_2; very few very fine to medium and few coarse roots
H8-9 described near an uprooted tree at about 20 m distance from the soil profile:		
H8	2Ahb	70-90 cm; black 10YR 1/1 (M), black 10YR 2/1 (D); silty clay; odour of decomposing organic matter under reduced conditions; strong, coarse platy breaking to angular blocks; hard; high porosity; few coarse roots; common white (10YR8/1, D), secondary carbonate coatings on ped faces; clear smooth boundary
H9	2Bkb	90-… cm; very dark greyish brown 10YR 3/2 (M, D); clay; angular blocky; friable; medium porosity; no roots; few distinct beige secondary carbonate coatings of ped faces

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Photo 34: The remaining of the forest plot hosting profile 801.

At the time of profile description the experimental plot had already been moved once due to a major tree fall during a heavy storm. In 2008 the plot has been moved completely to a nearby location with a more dense forest.

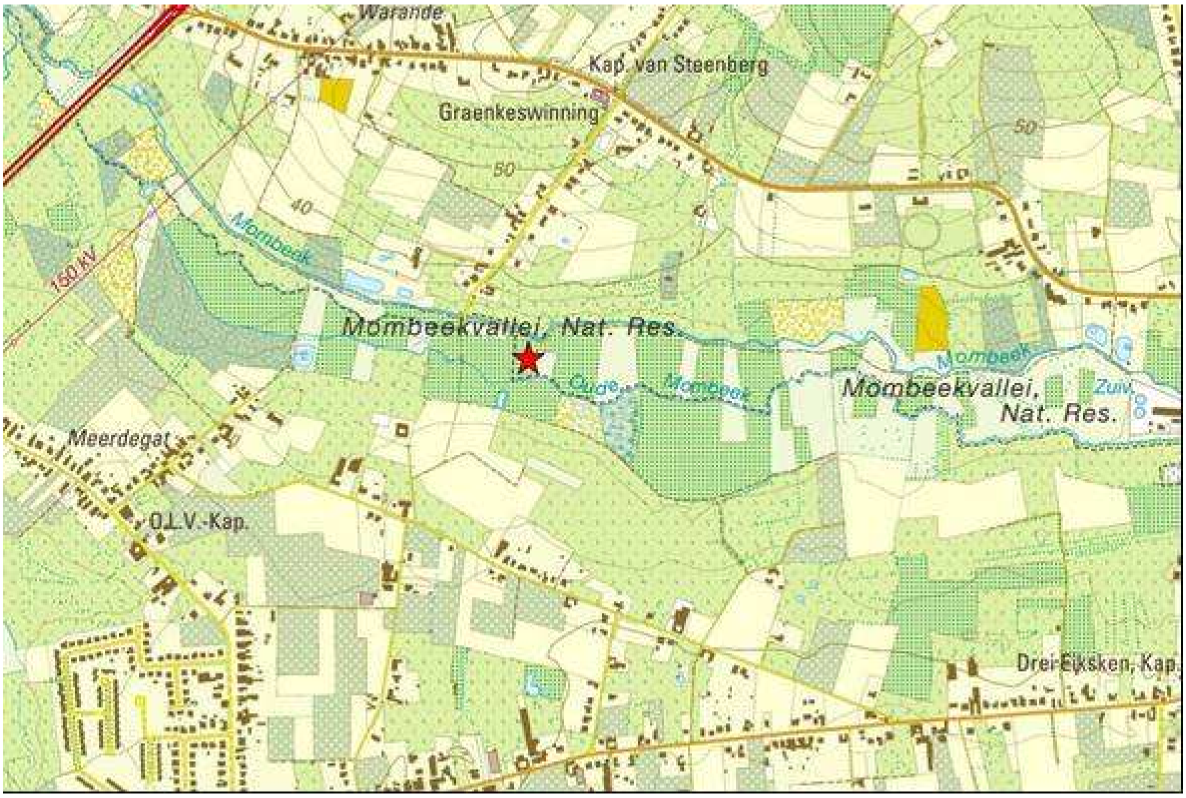

Figure 33: Topographical map of the tributary valley and surroundings hosting profile 801

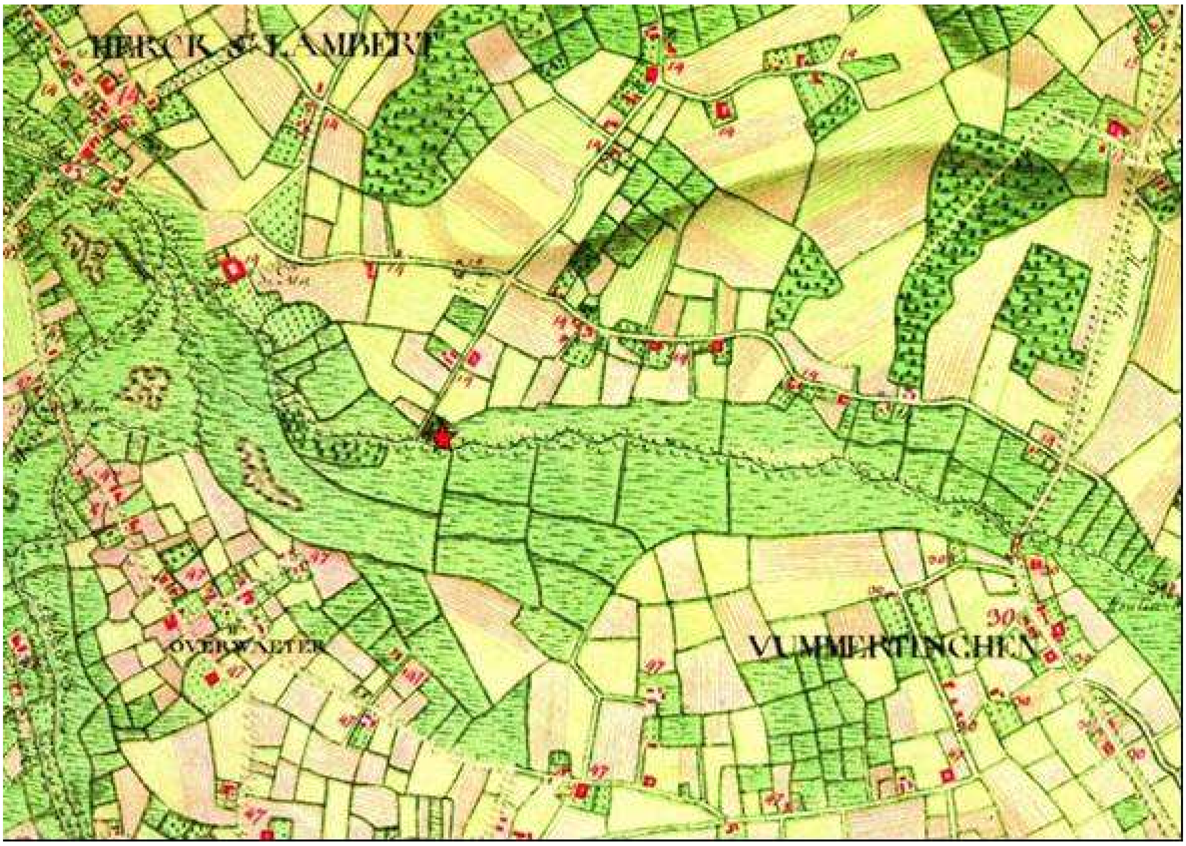

Figure 34: The landscape in the neighbourhood of profile 801 as it was interpreted when the Ferraris (1777) map was produced.

Photo 35: The extremely open canopy due to wide planting combined with uprooted trees has resulted in a monotonous nettle dominated vegetation (Photo JM)

Photo 36: The forest floor is very thin due to a very high biological activity resulting in a fast decomposition rate. The forest floor was classified as an Eumull (Photo JM).

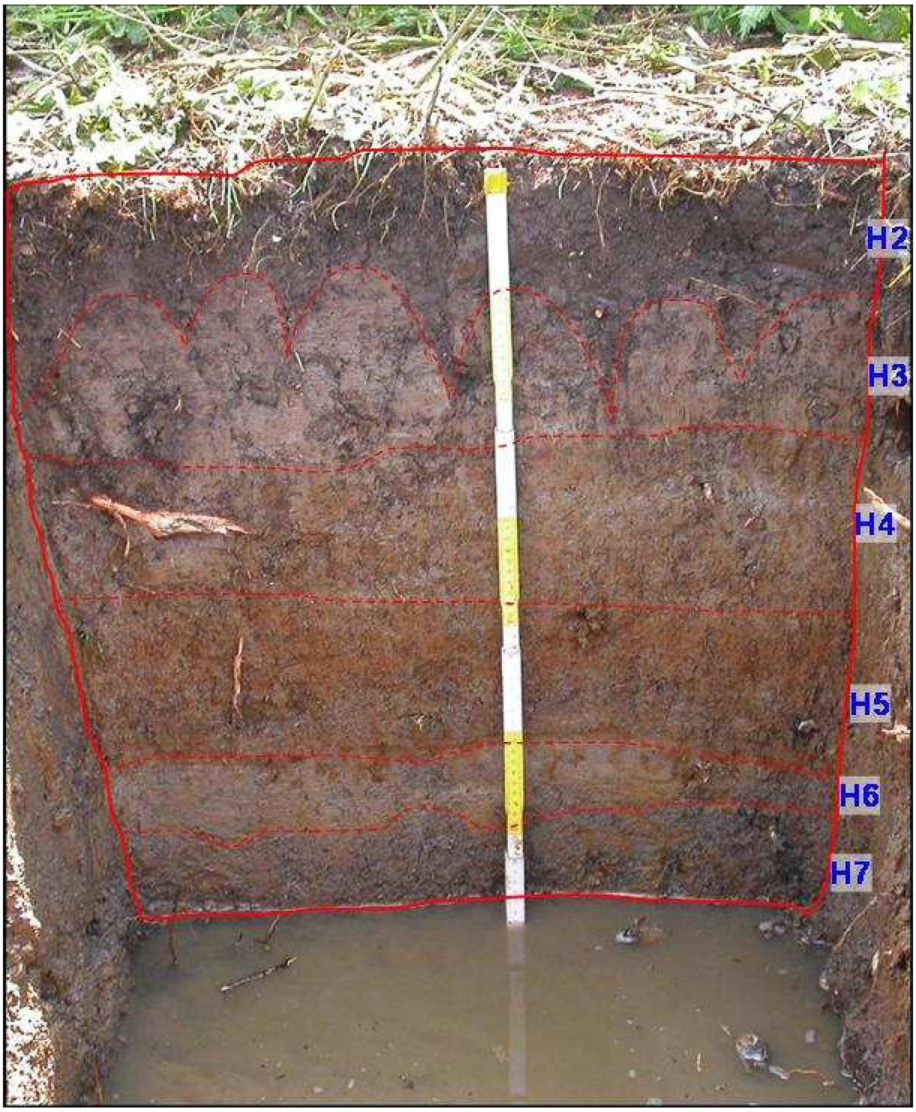

Photo 37: Soil profile P801, Wimmertingen with the 7 horizons recognised in the soil profile. Additional horizons located deeper than the water table were found on a complete uprooted tree (Photo JM).

12.2. Analytical data

This soil profile is very different than the other soils presented in this report. Primarily because of a very high clay content and high contents of basic cations. The C/N ratio is very good with values not exceeding 12, except for the dark part of H7 where the ratio is 13. Such low C/N ratio values form an excellent environment for earthworms, confirmed by the observations made during the fieldwork. The content of organic carbon is very high in several horizons, such as the A horizon with 8.1%, the dark part of the Cr horizon with 5.7% and the buried horizons recognised near the uprooted tree having 12.9% and 3.5% for the Ahb and the Bkb horizons respectively. The very high values of organic carbon measured by TOC are not recognised with the same magnitude for the values on Walkley and Black (Table 25). This is especially true for the A horizons which are relatively rich in organic matter. This may reflect the upper limit for accurate measurements using the latter analytical method.

The pH is slight acid to neutral with values of 6.1-7.3. In H3 the content of calcium carbonate was measured as high as 3%, but also in H5 1.1% was recorded. Although secondary calcium carbonate coatings were observed on structural faces in H9, the pH was only 6.7. It is indeed not uncommon that horizons containing secondary carbonate have a none-calcareous matrix.

Table 26: Analytical data for profile 801, Wimmertingen, Limburg, Belgium. Profile studied 12/5/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth	Total N (Kjeldahl) Modified	Total N (Kjeldahl) Standard	Org. Carbon TOC	Org. Carbon W&B	OM LOI	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm
		cm	%	%	%	%	%				%-wght
1	OLn	1-0									
2	A	0-10	0.746	0.776	8.10	4.8			6.1	5.6	
3	Btg1	10-26	0.241	0.201	1.53	1.3			7.1	6.4	
4	B(t)g2	26-37	0.088	0.094	0.50	0.6			7.3	6.1	
5	BCg	37-47			0.64	0.6			7.1	6.6	
6	Cg	47-54			0.48	0.4			7.3	6.8	
7	Cr (normal)	54-70	0.123	0.152	1.27	1.3			6.9	6.4	
7	Cr (dark part)	54-70	0.433	0.438	5.73	3.5			6.8	6.3	
8	2Ahb	70-90			12.89	9.0			6.2	5.9	
9	2Bkb	90-			3.51	3.7			6.7	6.4	

Horizon nr.	0-2	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
	Particle size distribution (fractions in µm) -----%-----										
1											
2	56.4	16.3	9.9	12.8	0.4	1.7	1.1	1.1	0.2	0.0	0.0
3	65.7	10.5	6.0	11.7	0.2	1.2	2.3	2.2	0.1	0.0	0.0
4	45.9	4.6	4.4	25.3	1.1	8.6	3.5	5.8	0.1	0.0	0.8
5	49.9	4.2	1.9	22.3	1.1	9.5	5.0	5.6	0.2	0.1	0.0
6	45.7	1.8	0.3	15.8	1.1	13.6	12.0	9.4	0.3	0.0	0.1
7	44.9	4.7	2.3	17.2	1.0	9.7	10.9	8.5	0.7	0.0	0.0
7											
8	56.9	21.3	8.0	11.9	0.1	0.6	0.8	0.9	0.1	0.1	0.0
9	60.9	10.8	6.3	17.7	0.3	0.5	1.5	1.9	0.0	0.0	0.0

Horizon nr.	Mg^{++}	Na^{+}	K^{+}	Ca^{++}	CEC	BS	CEC/ clay	Al Dithi. Citrate	Fe Dithi. Citrate	Al Oxalate	Fe Oxalate
	---by NH_4OAc--- cmol(+)/kg soil					%		%		%	
1											
2	3.85	0.06	0.51	43.99	42.3	>100	26				
3	3.51	0.08	0.24	26.99	22.7	>100	27			0.233	1.601
4											
5										0.077	0.651
6											
7	1.67	<0.22	<0.13	10.21	10.9	>100	20			0.062	0.704
7	2.24	<0.22	<0.13	13.75	17.7	>100	30				
8										0.159	0.947
9										0.083	7.218

Horizon nr.	Horizon symbols	Depth	Mg^{++}	Na^{+}	K^{+}	Ca^{++}	Al^{+++}	Fe^{+++}	Mn^{++}	Free H^{+}	Lab nr.
		cm	---by $MgSO_4$ (compulsive method)--- cmol(+)/kg soil								
1	OLn	1-0									JM130
2	A	0-10	3.43	<0.09	0.80	43.38	<0.17	<0.03	0.190	0.16	JM131
3	Btg1	10-26	1.57	0.14	0.43	16.09	<0.19	<0.03	1.429	1.82	JM132
4	B(t)g2	26-37									JM133
5	BCg	37-47									JM134
6	Cg	47-54	1.52	0.19	0.12	10.31	<0.04	<0.01	0.023	0.02	JM136
7	Cr (normal)	54-70	2.27	<0.09	0.17	15.16	<0.06	<0.01	0.016	0.03	JM137
7	Cr (dark part)										JM138
8	2Ahb	70-90									JM139
9	2Bkb	90-									JM140

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
	cmol(+)/kg		%	cmol(+)/kg		---Aqua Regia--- mg/kg					
1						4800	27937	1882	135	2027	2260
2	48.0	44.5	>100	0.3	0.7	8638	10855	6594	360	1322	1080
3	19.7	37.3	49	3.2	<3.8						
4						5196	4023	3978	206	410	174
5											
6	12.2	10.1	>100	0.4	<3.8	2802	2828	2133	165	600	146
7	17.9	16.7	>100	0.0	<3.8	3888	4506	3192	215	1000	310
7						8544	12094	6857	457	2583	917
8						9236	14930	6832	481	546	2847
9						4148	10399	3711	236	5946	919

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	---Aqua Regia--- mg/kg									dS/m 1:5	%
1	5747	2.86	13.3	6820	362	9	10.1	6.0	172		
2	46764	2.73	22.1	46987	1080	66	66.1	31.1	235	0.26	
3										0.11	3.0
4	27236	0.49	8.8	44163	510	41	14.5	18.5	57	0.05	
5										0.09	1.1
6	12846	0.23	4.3	28913	114	23	7.5	8.8	29	0.08	<0.5
7	20181	0.21	7.1	27989	209	32	10.4	13.5	42	0.10	
7	48051	0.53	15.8	64887	559	65	18.9	28.2	72	0.17	
8	49159	0.92	27.9	40714	678	66	17.3	36.4	82	0.17	
9	22972	1.84	15.5	241838	12699	35	16.6	38.4	92	0.28	

The particle size distribution is remarkable. Especially the clay content is extremely high with values ranging from 45-65%. In the samples collected near the uprooted tree and interpreted as buried topsoil horizons the content of fine silt is clearly higher than what is found for the other analysed horizons. The content of very fine sand increases with depth through the soil profile horizons. Due to high content of clay the horizons from this profile were not dry sieved on a 2-mm sieve. Instead they were crushed by a soil crusher, which would destroy any coarse fraction material. In the field anyhow no coarse fragments were observed.

The contents of basic cations are high to very high for all horizons, especially high calcium saturation was found. This is normal as free calcium carbonate is present in the pedon. A base saturation of 100% is observed throughout and the content of aluminium cations is very small and always below detection limit. The CEC of the clay is relatively low and has been calculated to 20-30 cmol(+)/kg clay. Maybe because the clay forms part of an alluvial sediment, meaning that it originates from somewhere upstream where it has been ageing before eroded and washed downstream.

A content of 1.6% oxalate extractable iron found in H3 is rather high, but the real concentration is found in H9 with 7.2%, which can be considered an extremely high content. The content of aqua regia extracted elements is very high for the elements normally found in a natural soil environment and moderate to low for the heavy minerals. An exceptionally high content of iron was found in H9, no less than 24%. It is not clear how this horizon has enabled to accumulate that much iron.

The bulk density is low to moderate and the content of water at field capacity is with values around 46-48% rather high (Table 26 and Figure 35). Unfortunately the content at wilting point is also high. This implies that the soil only can retain about 20% plant available water. With the location of this profile in the river valley the chance for drought is anyhow rather limited.

Table 27: Bulk density and water holding capacity for profile 801, Wimmertingen, Limburg, Belgium. One sample was taken at the transition between H6 and H7.

Horizon nr.	Horizon symbols	Depth cm	Actual water content %	BD_S soil g/cm3	BD_{FE} fine earth g/cm3		Lab nr.
1	OLn	1-0	50				JM130
2	A	0-10	99				JM131
3	Btg1	10-26	35	0.96	0.96		JM132
4	B(t)g2	26-37	25	1.26	1.26		JM133
5	BCg	37-47	35	1.28	1.28		JM134
6	Cg	47-54	29	1.41	1.41		JM136
7	Cr	54-70	35				JM137
7	Cr		92				JM138
8	2Ahb	70-90	14				JM139
9	2Bkb	90-	56				JM140

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	-- Vol. % water --							
1								
2								
3	54.0	49.5	48.6	47.8	47.1	46.7	34.3	11.4
4	57.8	50.4	48.9	47.6	46.6	46.1	25.4	5.3
5	57.2	49.0	47.1	46.0	44.3	43.0	35.4	27.6
6 / 7	54.4	53.0	50.5	48.4	40.0	36.7	28.9	21.4
7								
8								
9								

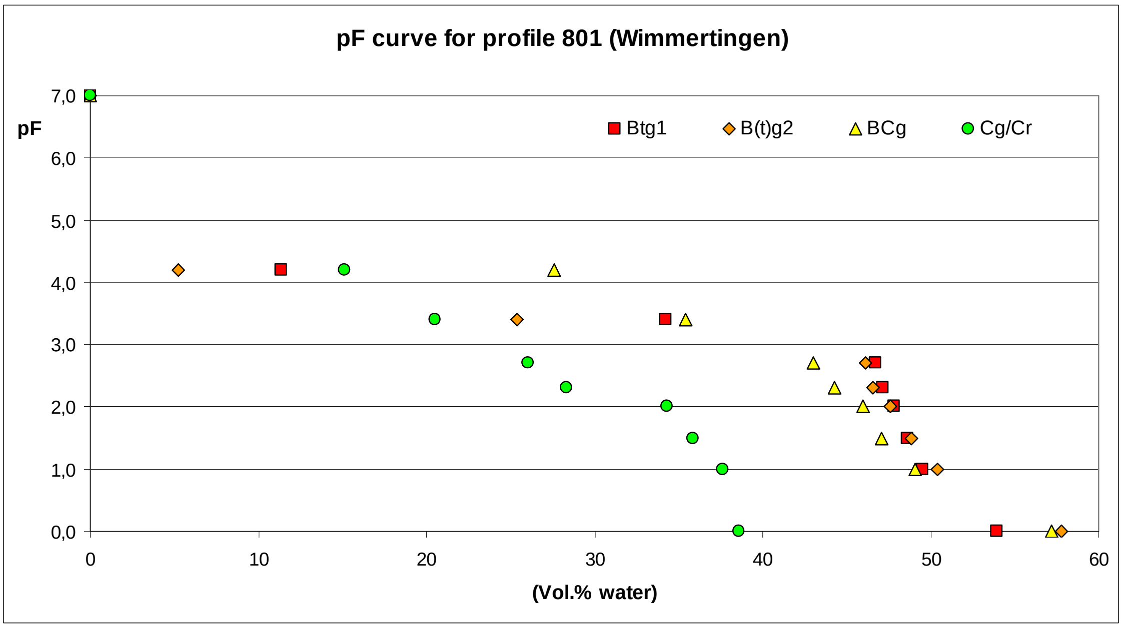

Figure 35: Water storage capacity in function of pF for profile 801, Wimmertingen.

12.3. Information deduced from the Belgian Soil Map

The southern most part of soil map Alken 92W is composed of loess soils with valley incisions. The central and northern part is made up of sandy loam soils. The soil profile is located in a valley characterised by Efp and Eep soil map units. To the south of the valley the soilscape includes the units Ldc, Lcc and with inclusions of Pdc, Pcc and Lhc (figure 35). To the north of the valley the soilscape is composed of u-Phc and w-Pdc with inclusions of Phc, Lep, Pcc and Scc.
The soil profile is located on the border between Eep and Efp (table 31).

Table 28: The soil map units present in the immediate surroundings of profile 801, Wimmertingen (after Baeyens and Tavernier, 1970)

Map symbol	Description
Eep	Strong gleyic soils developed in clayey material and reduction horizon
Efp	Very strong gleyic soils developed in clayey material and reduction horizon
Lcc	Weak gleyic sandy loam soils with strong mottles textural B horizon
Ldc	Moderate gleyic sandy loam soils with strong mottles textural B horizon
Lep	Strong gleyic soils developed in sandy loam material with reduction horizon
Lhc	Strong gleyic sandy loam soils with strong mottles textural B horizon
Pcc	Moderately dry fine sandy loam soils with degrading textural B horizon
Pdc/ w-Pdc	Moderately wet fine sandy loam soils with degrading textural B horizon
Phc/ u-Phc	Wet fine sandy loam soils with degrading textural B horizon, relatively high landscape position
Scc	Moderately dry loamy sand soils with degrading textural B horizon

Figure 36: Fragment of soil map Alken 92W (Baeyens and Tavernier, 1967) with soil profile P801, Wimmertingen indicated with a red star.

12.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H3	H3 qualify for an Albic horizon
Argic	H3	A strong clay increase is observed, but as the parent material is alluvium, the horizons illuvial character should be proved one way or another. Humus and clay coatings are observed (see horizon description), which is an indication of clay translocation.
Cambic		
Mollic		H2 qualifies except for thickness
Gleyic colour pattern	H3-6 H7	Oximorphic colour pattern Reductomorphic colour pattern
Reducing conditions	H2-7	
Fluvic material	H4-7	

Simplified classification name
Luvic Gleysol

Full classification name without specifiers
Luvic Gleysol (Humic, Eutric, Clayic) • Luvic: BS >100%, CEC/clay >24. • Humic: Weighted average 0-50 cm is 2.38 • Eutric: Through (most) of the profile the BS equals to 100% • Clayic: has a clayey texture with a clay content >45%

BioSoil classification name (WRB 2006), with specifiers
Luvic Gleysol (Humic, Hypereutric, Epiclayic)

The soil is dominated by Fluvic material starting at 26 cm depth. If the Fluvic material had started at 24 cm depth, the soil would have keyed out in Fluvisols. To find Gleysols associated with Fluvisols seems logic, it is therefore also remarkable that the Fluvic qualifier is not listed for Gleysols.

Advanced classification name (WRB 2006)
Luvic *Fluvic* Gleysol (Humic, Hypereutric, Epiclayic) • Fluvic is considered an important qualifier, and has therefore been placed in first position among the prefix qualifiers.

12.5. Discussion

Profile 801 is an example of a soil developed in fluvial material containing a high content of clay. The fluvial nature is clearly visible from H3 downwards (26 cm depth). Elsewhere a tree was uprooted in such a way that not only the horizon recognised in the soil profile but also two horizons located deeper than the water table had been preserved. From the field morphology and the analytical data it is most likely that these deeper horizons represent a buried soil, with an A and a B horizon. These horizons have extremely high contents of organic matter and very well developed pedality. Repetitive accumulations of materials is not uncommon for soils developing in a fluviatile environment.

The present day A horizon of profile 801 is characterised by cracks filled with organic rich material and worm casts. These cracks probably form a polygonal system and are related to desiccation of the topsoil in periods with low groundwater table and insufficient rain. Due to the high content of clay, the cracks can develop. Considerable clay migration was observed in the upper B horizon. Many of the coatings appeared as dusty, dirty and containing organic matter as well. These coatings are the result of sudden heavy input of water where material is flushed along. In the finer matrix and pores more shiny coatings were observed. Despite that, from 54 cm the soil appears as being permanently reduced. Roots were also observed at this level. Obviously the reducing conditions are not prevailing throughout the year or the roots of the poplars are particular resistant to oxygen depleted soil conditions.

Wimmertingen is a unique forest soil for Flanders when it comes to the physical and chemical characteristics. The clay content is very high, the soil has a neutral to slight basic pH regime and the content of basic cations remains above 100%. The soil's recent history shows that it was part of an active fluvial environment. Flooding still appears on an occasionally basis. Additionally after extreme weather conditions combined with a high groundwater table, nutrients may be rather added to the system than leached out. The combination of these three factors seems the most plausible explanation for the high contents of basic cations.

The classification name fits well the type of soil observed in the field, as earlier stated though it is a pity that the fluvial qualifier is not listed for Gleysols. Considering the close relation between Fluvisols and Gleysols more cases like Wimmertingen must exist, where in absence of the fluvial qualifier the important recent impact of fluvial material is otherwise ignored in the classification name.

The WRB-2006 soil classification name in this study correlates well with the FAO (1988) soil classification name of 'Eutric Gleysols' given by the soil surveyors in 1993.

13. Profile 803, Gellik, Limburg

13.1. Site and profile description

Profile 803	**Gellik (Level 1 forest plot)**
1.2 Date of description:	28/7/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	On highway E313 take exit 31 in northern direction (Bilzen) and turn immediately to the right along the road Alden (N700), which after a while becomes Biesensingel. At the end of the road turn right along Maastrichterstraat (N2). After about 2300 m turn left along Hoelbeekstraat, which is running towards north. After about 2700 m turn right and follow the Hoefaertweg over the Albert channel. Immediately after the bridge turn left and follow the road running parallel with the Albert channel in northern direction. After the first farm, take the first forest road on the right side. This road might be blocked for vehicles. After about 300 m the road splits, take the right road. The level 1 forest plot is situated between two forest roads (Photo 38), one located just before and one right after the water stream.
1.5 Profile coordinates:	*National plot nr.:* 803 *International plot nr.:* 58 50° 53' 42.85" N, 5° 34' 35.79" E (centre of forest plot)
1.6 Elevation:	60-65 m a.s.l.
2.1 Atmospheric climate and weather condition:	Rain shower during fieldwork. Prior to the profile description was a long period with maximum temperatures of more than 30°C.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* The level I forest plot is located on the west facing slope of a plateau. This plateau hosting the city Zutendaal has an altitude of about 100 m and is strongly eroded with deep incisions cut into the plateau by water streams particular on the slopes towards east and south and to less degree west. The region is characterised by altitudes between 50-105 m (Figure 37). *Meso topography:* The profile is located on a general west facing slope. On meso-scale the slope is convex towards the water streams to the south and to the north of the soil profile. *Landscape position:* Upper slope; in convex slope position *Slope form:* VV (convex, convex) *Slope gradient:* The overall slope gradient is 0.06%, the slope gradient on the site was not measured. *Slope length:* The length of the slope from the plateau to the Albert channel is about 1500 m *Slope orientation:* Dipping towards west.
2.4 Land-use:	Plantation forestry with selective felling *Wildlife:* protected *Grazing:* no grazing
2.5 Human influence:	Vegetation slightly disturbed (photo 39) Ditch system with mutual distance of 6 m oriented 310° NW
2.6 Vegetation:	Coniferous woodland

Tree layer		**Shrub layer**		**Herb layer**	
Scots Pine	*Pinus sylvestris*	Silver Birch	*Betula pendula*	Bilberry	*Vaccinium myrtillus*
		Pedunculate Oak	*Quercus robur*	Brambles	*Rubus sp.*
				Wood Ferns	*Dryopteris dilatata*
				European Honeysuckle	*Lonicera periclymenum*

2.7 Parent material:	Coversand (code 7220)

2.8 Drainage class:	Well drained *Availability of water:* insufficient
2.9 Internal drainage:	Never saturated
2.10 External drainage:	Neither receiving nor shedding water
2.12 Groundwater:	Very deep (150-200 cm)
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	No erosion or sedimentation observed
2.17 Surface cracks:	None
Humus classification:	Despite the input of deciduous leaves to the forest floor the border to the underlying mineral soil is rather sharp and faunal activity is absent. The uppermost mineral horizon is an Ap horizon. The sequence of horizons is OL, OFnoz, OHnoz, Ae (photo 40) *Classification name:* Mor → Hemimor
Remarks:	The stone content in the Bh horizon is higher according to laboratory data than the field estimates given in the horizon description, and stones are also present in the overlying E and the underlying Bhs horizon, which was not observed during fieldwork.

No.		**Horizon description** (see also photo 41)
H1	OL	-10 till -8 cm; continuous litter layer of mainly, pine needles, birch and oak leaves
H2	OFnoz	-8 till -1 cm; partly decomposed leaves and needles; very dark brown 7.5YR 2.5/2 (M, W)
H3	OHnoz	-1-0 cm; completely decomposed, continuous; black 10YR 2/1 (M, W); clear smooth boundary
H4	Ap/Ae	0-16/20 cm; very dark grey to very dark greyish brown 10YR 3/1.5 (M), grey to greyish brown 10YR 5/1.5 (D); many (20-25%, right side of profile wall) to none (0% left side of profile wall), medium to coarse (1-3 cm), distinct, sharp, white, leopard-like microbio[1] mottles; sand; single grain; soft; common very fine to coarse roots; abrupt smooth boundary
H5	E	16/20-27/32 cm; brown 7.5YR 4.5/2 (M), grey to pinkish grey 7.5YR 6/1.5 (D); common (10-15%), medium to coarse (1-3 cm), distinct, sharp, light grey (10YR 7/2; D) leopard-like microbio[1] mottles; sand; single grain; soft; very few very fine roots; gradual smooth boundary
H6	Bh	27/32-37/47 cm; very dark greyish brown 10YR 3/2 (M), dark greyish brown 10YR 4/2 (D); sand; many (15-20%), subrounded to subangular, fresh, gravels and stones, mostly in the coarse gravels (2-6 cm) fraction but also stones up to 12 cm diameter, weak developed cappings on stones; single grain; soft; few very fine to fine roots; clear smooth boundary
H7	Bhs	37/47-65/67 cm; very dark greyish brown 10YR 3/2 (M), yellowish brown 10YR 5/4 (D); many (20-25%), medium to coarse (0.8-4 cm), distinct, clear, light greyish leopard-like microbio[1] mottles; sand; single grain; loose; irregular, horizontal humus migration fibres of 1-3 mm diameter; few very fine to medium roots; abrupt smooth boundary
H8	Bs	50-65/67 cm; yellowish brown 10YR 5/6 (M), brownish yellow 10YR 6/6 (D); sand; single grain; hard; discontinuous weakly cemented by iron oxides; very few very fine to fine roots; a horizontal darker band of 1-1.5 cm thickness is found at 56 cm depth and is dipping upwards on the left side of the wall (possible old filled crack); gradual smooth boundary
H9	Pocket	40-68 cm; very dark greyish brown to dark greyish brown 10YR 3.5/2 (M), brown 10YR 4.5/3 (D); sand; single grain; slightly hard; very few, very fine to fine roots and few coarse roots; possible a vertical meso-faunal bio-gallery, 5 cm diameter, today filled with stratified light greyish and brownish material (studied also on a horizontal section); broken clear boundary
H10	2BC	65/68-85 cm; light olive brown 2.5Y 5/3 (M), light yellowish brown 2.5Y 6/3.5 (D); sandy clay loam; massive; friable; very few medium to coarse roots;

		gradual smooth boundary
H11	2C1	85-150 cm; light olive brown to light yellowish brown 2.5Y 5.5/3 (M), pale yellow 2.5Y 7/3 (D); sandy loam; massive; friable; very few fine to medium roots, effective root depth is 150 cm; clear smooth boundary
H12	2C2	150-170 cm; brown to light olive brown 1.5Y 5/3 (M), brownish yellow 10YR 6/7 (D); sandy loam; massive; very friable; no roots; clear smooth boundary
H13	2Cg	170-182 cm; light olive brown 2.5Y 5/4 (M), light yellowish brown 1.5Y 6/4 (D); sandy loam; massive; very friable; no roots; clear smooth boundary
H14	2Cr	182-… cm; olive brown 2.5Y 4/3 (M), light brownish grey 1.5Y 6/2 (D); no reaction to α, α-dipyridyl; sandy loam; massive; no roots

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

[1] Leopard-like mottles= due to bacterial consumption of the organic material present in the soil matrix, rounded mottles are formed. Such mottles are commonly found in well drained Podzol like soils although they also are found in other sandy soil types.

Photo 38: The forest where profile 803 is located (Photo JM)

Photo 39: The immediate surroundings of profile 803 (Photo JM)

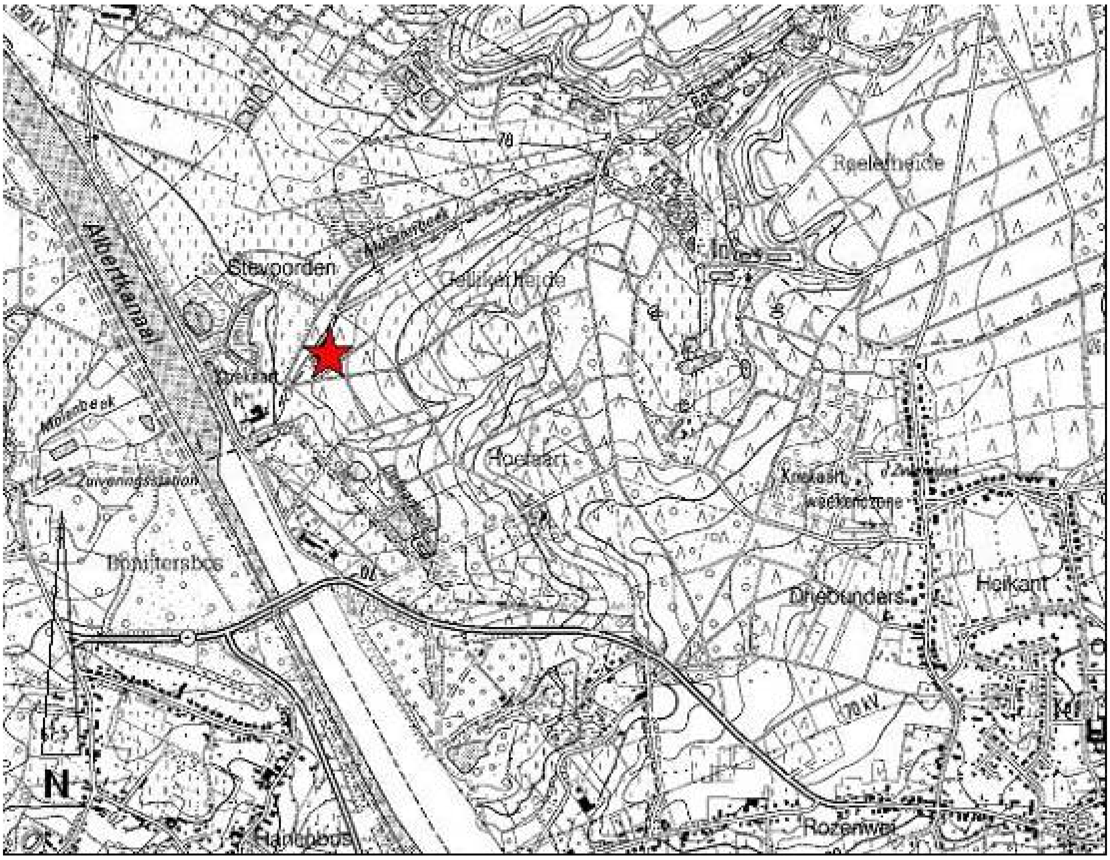

Figure 37: Topographical map of the area in the immediate surroundings of profile 803, Gellik. The red star indicates the profile location.

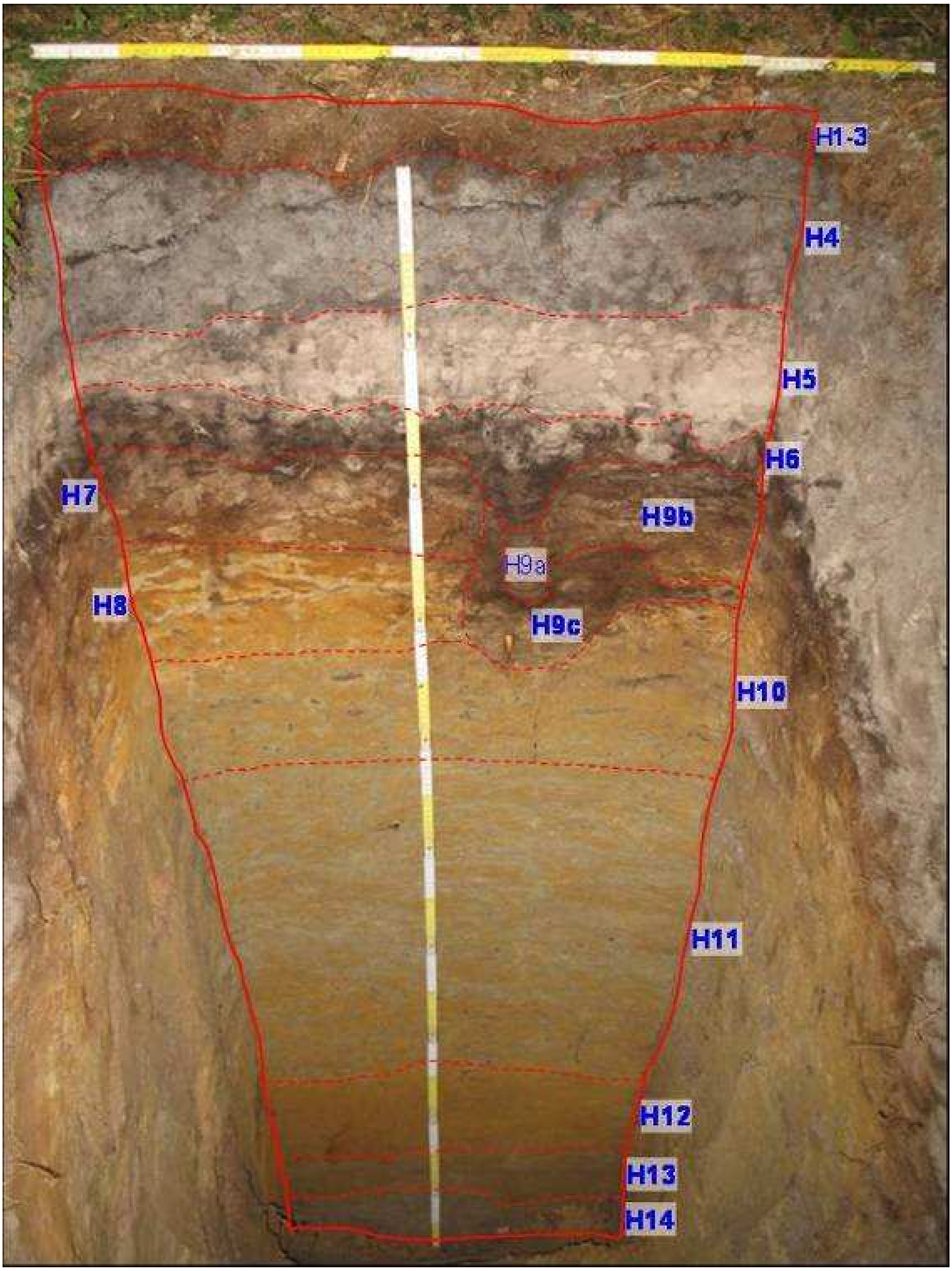

Photo 40: Soil profile 803, a Podzol like soil with a finer textured subsoil.

Photo 41: Detail of the organic soil layers. The forest floor was classified as a Hemimor.

13.2. Analytical data

Table 28 shows that the C/N ratio is high (>20) in the litter layer and the Ap horizon and drops to values between 12-19 in the subsoil, which are moderately good to poor values. In the E horizon the C/N ratio is only 3 because organic carbon is practically absent here. Small peaks in the content of organic carbon are found in the Bh-Bhs horizons and the pockets H9a-b. The pH is very acid in the upper horizons, increases a bit in the lower pedon and drops a bit again in the parent material. Coarse fractions are present in the upper 9 horizons only, below no gravel was found, this indicates the presence of a lithological discontinuity, as observed during the fieldwork.

The particle size distribution confirms the presence of a lithological discontinuity with an increase in clay from H4-9 ranging from 0.6-4.5% towards H10-14 with 10.9-21.0%. H10-14 have considerable less sand in the fraction 125-250µm, opposite to the content of the silt fractions which remain very similar through the profile.

Like for the other sandy profiles (e.g. 505 and 602), the content of basic cations is extremely low below the litter layer. An increase in the CEC from H10 onwards is not reflected in the base saturation which remains extremely low. The CEC of the clay is in the range of 40-50, which may indicate that the clay minerals are of the illite type or a combination of clays with a higher CEC level with clays of low CEC. In any case, a range of 40-50 is typically for Flemish soils, having experienced some aging but nothing like what is found in deeply weathered tropical soils. The CEC is from H7 onwards dominated by aluminium with a saturation of 85-93%, which can be toxic for some plants (Table 28).

The increase in the content of dithionite iron and aluminium towards H9-10, is not shared by the oxalate iron and aluminium content. The absence of any peak for the horizons described in the field as the Bh, Bhs and Bs horizons could point towards a podzolisation process still in a premature stage. Today in the profile merely expressed by the typical Podzol colour pattern with a bleached E, a dark brown to blackish Bh and a reddish brown to orange brown Bhs or Bs horizon above each other.

The data on aqua regia extracted elements shows remarkable high values of potassium, a trend that is not observed for the basic cations extracted by ammonium acetate nor by the magnesium sulphate extracted potassium.

Table 29: Analytical data for profile 803, Gellik, Limburg, Belgium

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Total N (Kjeldahl) Standard %	Org. Carbon TOC %	Org. Carbon W&B %	OM LOI %	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm %-wght
1	OL	10-8									
2	OF	8-1	1.815				93		3.6	2.8	
3	OH	1-0	1.282				74		3.5	2.6	
4	Ap	0-16/20	0.057	0.049	1.18	1.0			3.9	3.2	1.3
5	E	16/20-27/32	0.035	0.02	0.10	<0.1			4.2	3.8	12.5
6	Bh	27/32-37/47	0.081	0.081	1.35	1.3			3.9	3.3	6.2
7	Bhs	37/47-65/67	0.055	0.061	0.94	0.6			4.1	3.6	17.1
8	Bs	50-65/67	0.041	0.087	0.52	0.4			4.5	4.2	0.4
9a	pocket	40-68	0.055	0.053	1.04	0.9			4.2	3.8	5.8
9b	pocket	40-68	0.069	0.051	1.05	0.9			4.4	4.1	0.7
10	2BC	65/68-85			0.42	0.2			4.3	3.8	0.0
11a	2C1	85-150			0.23	<0.1			4.3	3.7	0.0
11b	2C1	85-150			0.26	<0.1			4.0	3.6	tr
12	2C2	150-170			0.24	<0.1			4.1	3.6	0.0
13	2Cg	170-182			0.23	<0.1			4.1	3.6	0.0
14	2Cr	182-...			0.21	<0.1			4.1	3.6	0.0

Horizon nr.	0-2	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
	Particle size distribution (fractions in µm) --- % ---										
1											
2											
3											
4	0.6	0.8	2.2	6.0	1.7	25.9	28.6	31.5	2.3	0.4	0.2
5	0.6	0.9	1.2	5.7	1.3	25.8	28.5	32.2	2.9	0.6	0.1
6	4.1	1.2	1.5	4.0	1.0	19.4	25.6	35.7	4.6	1.2	1.4
7	3.1	0.3	1.5	3.6	0.9	19.5	24.9	38.2	5.0	1.2	1.8
8	4.5	1.7	1.5	2.5	0.5	13.7	21.9	44.6	6.6	1.7	0.8
9a	2.7	0.5	1.3	3.5	0.9	20.0	26.4	38.1	4.7	1.0	0.8
9b	2.7	0.3	1.5	3.1	0.8	16.4	26.4	41.4	5.3	1.3	0.8
10	21.0	2.6	2.8	5.1	1.2	18.3	48.6		0.4	0.0	0.0
11a	16.7	3.0	3.1	5.9	1.9	22.4	25.9	21.0	0.0	0.0	0.0
11b	16.1	2.3	2.5	5.2	1.0	19.3	33.2	20.5	0.1	0.0	0.0
12	14.7	2.0	0.9	6.8	1.1	32.3	30.8	11.4	0.1	0.0	0.0
13	15.5	1.3	0.3	6.8	1.4	33.3	31.5	9.6	0.0	0.0	0.0
14	10.9	2.3	0.2	6.3	47.9		25.5	6.1	0.0	0.0	0.0

Horizon nr.	Mg++	Na+	K+	Ca++	CEC	BS	CEC/ clay	Al Dithi. Citrate	Fe Dithi. Citrate	Al Oxalate	Fe Oxalate
	by NH_4OAc cmol(+)/kg soil'					%		%		%	
1											
2	2.02	0.25	1.01	12.9	98.7	16				0.05	0.08
3	1.03	0.20	0.63	9.6	97.5	12				0.08	0.15
4	<0.28	<0.22	<0.13	<0.5	3.0	~19				0.01	0.01
5	<0.28	<0.22	<0.13	<0.5	0.5		26	0.00	0.00	<0.01	<0.01
6										0.07	0.02
7	<0.28	<0.22	<0.13	<0.5	6.1	~9		0.16	0.01	0.03	<0.01
8	<0.28	<0.22	<0.13	<0.5	4.2	~13	55	0.15	0.05	0.02	0.01
9a								0.20	0.01	0.01	<0.01
9b								0.25	0.01	0.12	<0.01
10	0.11	0.02	0.17	0.2	10.6	5	44	0.56	0.09	0.09	0.07
11a	<0.28	<0.22	<0.13	<0.5	9.1	~6	50				
11b											
12	<0.28	<0.22	<0.13	<0.5	6.9	~8	41				
13	<0.28	<0.22	0.17	<0.5	7.6	~9	44	0.21	0.06	0.06	0.03
14	<0.28	<0.22	0.14	<0.5	6.4	~10	53	0.10	0.01	0.08	0.02

Horizon nr.	Horizon symbols	Depth cm	Mg++	Na+	K+	Ca++	Al+++	Fe+++	Mn++	Free H+	Lab nr.
			by $MgSO_4$ (compulsive method) cmol(+)/kg soil								
1	OL	10-8									JM166
2	OF	8-1	1.49	0.15	1.03	15.87	1.46	0.19	0.238	9.51	JM167
3	OH	1-0	<0.6	0.12	0.58	11.55	3.65	0.48	0.084	5.86	JM168
4	Ap	0-16/20	<0.13	<0.02	0.02	0.19	0.47	<0.01	<0.002	0.67	JM169
5	E	16/20-27/32	<0.12	<0.02	<0.01	<0.02	0.07	<0.01	<0.002	0.20	JM170
6	Bh	27/32-37/47									JM171
7	Bhs	37/47-65/67	<0.12	<0.02	0.04	0.25	2.96	0.02	<0.002	0.23	JM172
8	Bs	50-65/67	<0.12	<0.02	0.03	0.07	1.52	0.05	<0.002	0.03	JM173
9a	pocket	40-68									JM174
9b	pocket	40-68									JM175
10	2BC	65/68-85	<0.12	<0.02	0.17	0.29	8.42	0.02	<0.002	0.14	JM176
11a	2C1	85-150	<0.12	<0.02	0.17	0.36	5.66	<0.01	<0.002	0.09	JM177
11b	2C1	85-150									JM178
12	2C2	150-170	<0.12	<0.02	0.15	0.15	4.53	<0.01	<0.002	0.10	JM179
13	2Cg	170-182	<0.12	<0.02	0.17	0.16	4.89	<0.01	<0.002	0.10	JM180
14	2Cr	182-...	<0.12	<0.02	0.15	0.14	4.46	<0.01	<0.002	0.10	JM181

Table 28 (continued): Analytical data for profile 803, Gellik, Limburg, Belgium. Profile studied 28/7/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
	cmol(+)/kg	cmol(+)/kg	%	cmol(+)/kg	cmol(+)/kg	Aqua Regia mg/kg					
1						1249	7705	648	78	686	1619
2	29.9	31.0	60	11.4	11.5	632	2983	341	90	609	2679
3	22.3	34.0	<37	10.1	15.8	558	2256	232	92	499	2312
4	1.35	<4	~14	1.1	1.4	190	103	45	35	32	61
5	0.26	<4	~4	0.3	0.4	241	62	28	24	15	19
6						1237	210	523	64	125	98
7	3.5	<4	~18	3.2	3.4	1131	162	486	31	96	64
8	1.7	<4	~8	1.6	1.7	1589	104	801	37	61	91
9a											
9b											
10	9.0	7.5	<7	8.6	7.2	6394	147	3301	169	69	104
11a	6.3	6.7	<9	5.8	6.2	5822	209	3168	206	102	150
11b											
12	4.9	5.3	<7	4.6	5.0	2666	92	1282	30	60	165
13	5.3	5.9	<7	5.0	5.4						
14	4.9	5.4	<7	4.6	4.9	2306	104	1252	34	42	71

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	Aqua Regia mg/kg									dS/m 1:5	%
1	420	0.92	10.1	598	326	2	17.0	4.3	225		
2	1309	1.02	14.4	2443	88	7	65.3	9.3	168	0.07	
3	2375	0.98	24.3	4908	57	11	210.5	12.2	143	0.11	
4	1063	0.12	1.6	313	4	4	9.5	0.7	6	0.02	
5	810	0.02	0.4	161	4	5	1.6	0.5	6	0.01	
6	5921	0.35	0.7	2629	9	14	6.3	1.5	13	0.04	
7	5244	0.24	0.5	3418	10	15	3.3	1.3	12	0.03	
8	8680	0.24	1.0	15811	9	21	5.5	1.7	14	0.02	
9a										0.02	
9b										0.02	
10	30067	0.37	3.4	24975	15	68	6.1	5.9	28	0.05	
11a	24242	0.24	5.2	17004	15	65	4.7	5.5	25	0.04	
11b										0.06	
12	6699	0.26	7.8	26885	5	39	4.2	1.9	16	0.04	
13										0.04	
14	6265	0.08	6.7	7385	4	34	2.8	2.0	17	0.05	

The bulk density is rather low for the four horizons analysed (1.0-1.3 g/cm^3). As expected considering the sandy nature of this soil, the water holding capacity at field capacity is low (Table 29 and Figure 38).

Table 30: The bulk density and the water holding capacity for profile 803, Gellik.

Horizon nr.	Horizon symbols	Depth	Actual water content	BD_S soil	BD_{FE} fine earth	Lab nr.
		cm	%	g/cm3	g/cm3	
1	OL	10-8	110			JM166
2	OF	8-1	57			JM167
3	OH	1-0	78			JM168
4	Ap	0-16/20	4	1.02	0.99	JM169
5	E	16/20-27/32	2	1.25	1.25	JM170
6	Bh	27/32-37/47	1			JM171
7	Bhs	37/47-65/67	6			JM172
8	Bs	50-65/67	9	1.27	1.27	JM173
9a	pocket	40-68	7			JM174
9b	pocket	40-68	5			JM175
10	2BC	65/68-85	18	1.29	1.29	JM176
11a	2C1	85-150	15			JM177
11b	2C1	85-150	15			JM178
12	2C2	150-170	22			JM179
13	2Cg	170-182	24			JM180
14	2Cr	182-…	28			JM181

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	Vol. % water							
1								
2								
3								
4	48.9	44.5	38.9	24.0	17.3	15.5	4.1	1.4
5	53.5	49.9	47.9	26.5	19.5	17.0	2.5	1.2
6								
7								
8	50.0	46.2	39.3	25.3	20.8	19.8	7.6	6.0
9a								
9b								
10	51.4	48.0	41.9	27.4	21.2	20.3	25.7	19.8
11a								
11b								
12								
13								
14								

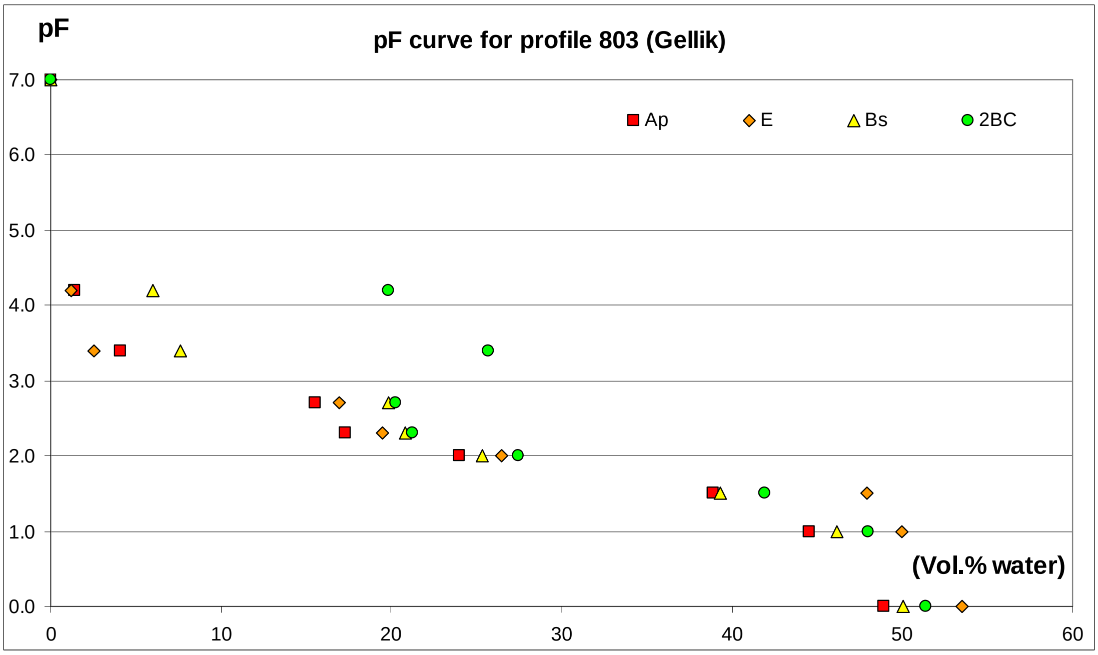

Figure 38: The water content in function of the pF for profile 803, Gellik

13.3. Information deduced from the Belgian Soil Map

The soil map Veldwezelt 93E & Neerharen 94W borders to the east to The Netherlands. Most of the map is composed of loess soils with valley incisions. To the north of the Albert Channel the soils becomes coarser textured (Figure 39).

The soil profile is included in the map unit Sdg. In the immediate surroundings a rather complex soil pattern is found with inclusions of Sbf, Scf, Scm, Sdm, Seg, Sfp, Zag, Zdg, s-Lep, s-Lfp (Table 30). Immediate to the south the Sfp inclusion marks a drainage valley. To the north of the Sdg map unit the s-Lep and s-Lfp units marks the Munsterbeek drainage valley.

Table 31: The soil map units present in the immediate surroundings of profile 803, Gellik (after Baeyens and Tavernier, 1968)

Map symbol	Description
Sdg	Moderately wet loamy sand soils with clear humus and/or iron B horizons
g-Sdg	Idem, but with stony substratum starting at shallow depth.
Sfp	Very wet soil on loamy sand. Alluvial deposits without profile development.
s-Lep	Strong gleyic soils on sandy loam with reduction horizon. Sand substratum starting at shallow depth (20-80 cm)
s-Lfp	Very strong gleyic soil on sandy loam with reduction horizon. Sand substratum starting at shallow depth (20-80 cm)

The map unit of the soil profile is “Sdg” with a moderately thick humeferous topsoil of 20-40 cm thickness. The soil is described as hydromorphic humus iron Podzol. The A or Ap topsoil is very dark grey to black and the E horizon is light greyish. The B horizon is composed of a black B horizon and a reddish brown humus or iron B horizon. The soil is developed in aeolian sediments. Commonly the rusty mottles are lacking in those Sdg soils that have developed in aeolian sediments. Instead a diffuse and deep Podzol has developed with the horizon sequence Bh, Bir Bg Cg.

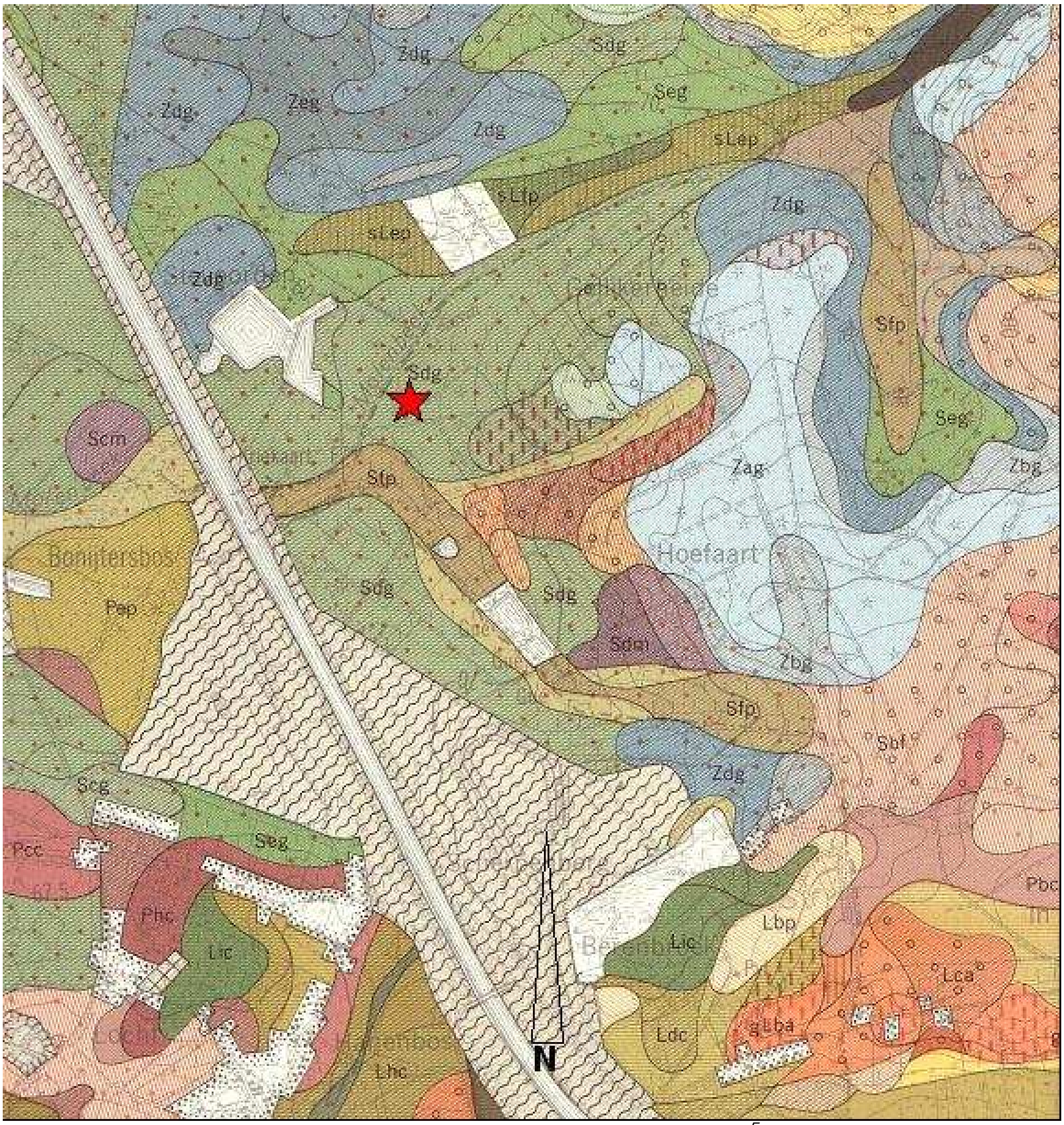

Figure 39: Soil profile 803 (red star) is situated on soil map Veldwezelt 93E & Neerharen 94W (Baeyens and Tavernier, 1965).

13.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H5	
Folic	H1-3	Just exactly 10 cm thick
Spodic	-	Colours have too high chroma
Abrupt textural change	Upper limit of H10	H9b has a texture similar to H8. H9c has not been analysed fore its particle size distribution but it is assumed to be similar to H9a and H9b. The limit of the abrupt textural change is therefore at the upper limit of H10
Gleyic colour pattern	H13-14	
Lithological discontinuity	Upper limit H10	

Simplified classification name
No diagnostics present that would qualify for a certain soil reference group. The soil is sandy to a depth of 67 cm. With depth it becomes sandy clay loam to sandy loam. Due to a finer textured bottom part of the soil, it is not an Arenosol. **Haplic Regosol**

Full classification name without specifiers
Haplic Regosol (Dystric, Arenic) • Humic: Weighted average of 0.92% OC is not enough

BioSoil classification name (WRB 2006), with specifiers
Haplic Regosol (Hyperdystric, Epiarenic)

Advanced classification name (WRB 2006):
Haplic Regosol (Hyperdystric, Epiarenic) [Albic, Protospodic] • Albic and Protospodic are added between a second set of brackets. Albic is present in the soil but not listed for Regosols and Spodic is present but insufficient developed to qualify the taxonomic criteria.

13.5. Discussion

When comparing this profile with other sandy soils such as profile 505 and 602. One major difference is that in profile 803 from about 65 cm depth the soil contains 10-20% clay. This implies that water and nutrients can be stored longer in the profile and that the clays upon weathering releases nutrients. This may explain why the podzolisation in this profile is in an earlier stage than observed for previous mentioned two profiles. A second factor not explored further in this report is time. Possibly the sediment wherein the soil has developed is of a younger age or a phase of erosion has occurred before a new phase of pedogenesis could take place. It is a fact that profile 803, Gellik is located relatively close to the Meuse river and on the edge of a plateau, which shows many geomorphologial evidences of fluvial erosion. Although the soil is not classified as a Podzol the colour pattern indicates that the soil to some degree has been podzolised. Unfortunately this is not expressed in the classification name. A more correct name would be if a qualifier Hypospodic could be added to indicate that this soil will with time probably will develop into a Podzol.

The WRB-2006 soil classification name in this study does not correlate directly with the FAO (1988) soil classification name of 'Carbic Podzols' given by the soil surveyors in 1993. According to them, the podzolic nature of this soil was expressed sufficiently to classify this soil in the major soil grouping of the Podzols.

14. Profile 901, Hechtel-Eksel, Limburg

14.1. Site and profile description

Profile 901	**Pijnven (Level 1 forest plot)**
1.2 Date of description:	26/06/2006
1.3 Author:	Jari Hinsch Mikkelsen
1.4 Location:	Belgium, Province of Limburg, Hechtel-Eksel municipality. On motorway E314 take exit 29 direction Houthalen along N715. Follow this road, after about 15.5 km the road leads through the Pijnven forest. Drive for another 2750 m and take the gravel road on the left side leading deeper into the forest. After about 800 m along this road, follow the road to the left of the forest hut for about 2400 m. Between the 6th and the 7th side road the Level I forest plot is located on the right (Photo 42).
1.5 Profile coordinates:	*Country code:* 201 *Code plot:* 32 *Code profile:* 901 *Latitude, longitude:* 51° 10' 06.61" N, 5° 19' 06.93" E
1.6 Elevation:	55 m a.s.l.
2.1 Atmospheric climate and weather condition:	Strong rain on the day prior to fieldwork. During the fieldwork it was dry and overcast.
2.2 Soil climate:	*STR:* Mesic *SMR:* Udic
2.3 Topography:	*Macro topography:* Pijnven is a plantation planted partly to prevent further wind erosion and partly to provide timber for the coal mines that was explored in this region until a few decades ago. The landscape is generally rather flat, with gently incisions hosting the water streams (figure 40, 41 and 42). *Meso topography:* At many locations within the forest the meso-topography is completely dominated by wind erosion and sedimentation, in form of dunes and even parabolic dunes. *Landscape position:* upper part of a very gently rolling landscape position *Slope form:* CV (concave, convex) *Slope gradient:* Almost flat, not to be measured in the field. *Slope length:* The slope dips very gentle towards the water stream Grote Nete located about 1000 m to the south. Over this length the altitude decreases from 55 m to 50 m. *Slope orientation:* South
2.4 Land-use:	Plantation forestry with selective felling. Some natural regeneration. *Wildlife:* regulated *Grazing:* none, except by roe deer
2.5 Human influence:	Vegetation slightly disturbed. Partly due to a single time ploughing partly when the ditch system was created (photo 43).
2.6 Vegetation:	Coniferous woodland with >90% Black Pine. On the edges of the forest plot a few Northern Red Oaks are growing

Tree layer		**Shrub layer**		**Herb layer**	
Black Pine	*Pinus nigra subsp. Laricio*			Hair grass	*Deschampsia flexuosa*
				Wood Ferns	*Dryopteris dilatata*
				Black Pine	*Pinus nigra subsp. Laricio*
				Sheep Fescue	*Festuca filiformis*
				Mountain Ash	*Sorbus aucuparia*
				Purple Moor Grass	*Molinia caerulea*
				Sheep's sorrel	*Rumex acetosella*
				Narrow Buckler Fern	*Dryopteris carthusiana*

2.7 Parent material:	Cover sand (7220)

2.8 Drainage class:	Somewhat excessively drained *Availability of water:* insufficient
2.9 Internal drainage:	Never saturated
2.10 External drainage:	Slow run-off
2.12 Groundwater:	Extremely deep (>200 cm)
2.13 Rock outcrop:	None
2.14 Coarse surface frag.:	None
2.15 Erosion, sedimentation:	The soil is disturbed by ploughing and scarred by old ditches, today filled so they are not always visible from the surface topography.
2.17 Surface cracks:	None
Humus classification:	The forest floor is composed of an OL, OFnoz, OH horizon sequence overlying a mineral horizon (photo 44). Latter has an important fraction of bleached quartz grains. For the purpose of classifying the humus type this uppermost mineral horizon is interpreted as an E horizon. *Classification name:* Mor → Eumor
Remarks	The soil has been deeply ploughed ones, and a ditch is present at the level of the front wall. For this reason also the right profile wall is included in the soil description. No leopard-like mottles were observed.

No.		**Horizon description** (see also photo 45)
H1	OL	-6 till - 4 cm; undecomposed and slightly decomposed needles and dead mosses
H2	OF	-4 till - 1 cm; very dark brown 7.5YR 2.5/2 (M); partly decomposed needles
H3	OH	-1-0 cm; black 7.5YR 2.5/1 (M), continuous
H4	A/Ep	0/5-12/20 cm; Ap: black 7.5YR 2.5/1 (M), very dark grey 10YR 3/1 (D), E: dark grey 10YR 4/1 (M); sand; common, flat, subangular and angular, fresh, coarse gravels to boulders (largest one observed is 28 cm long), mixed mineralogy; single grain; very friable; common very fine to medium roots; single earthworm observed; salt and pepper, composed of bleached sand grains and humus fragments; complex abrupt boundary
H5	Bh1	12-42 cm (pockets); black 10YR 1/1 (M), black 10YR 2/1 (D); loamy sand; common, subrounded and subangular, fresh, medium gravels to stones, mixed mineralogy; single grain; friable; few very fine to coarse roots; broken abrupt boundary
H6	Bh2	12/42-50/60 cm; upper part: very dark grey to very dark greyish brown 10YR 3/1.5 (M), dark greyish brown to brown 10YR 4/2.5 (D), lower part: brown to light olive brown 1.5Y 5/3 (M), pale brown to light yellowish brown 1.5Y 6/3 (D); sand; common, subrounded and subangular, medium gravels to stones, mixed mineralogy; single grain; upper part very friable, lower part loose; broken, massive, weakly cementation by organic matter; common very fine to medium and few coarse roots; smooth gradual boundary
H7	C1	50/60-95/100 cm; light yellowish brown to pale yellow 2.5Y 6.5/3 (M), light grey 2.5Y 7/2 (D); sand; no stones; single grain; loose; very few very fine to fine roots, below 50 cm roots are restricted to the vertical by-pass flows; smooth diffuse boundary
H8	C2	95/100-… cm; colours as for H7; sand; no stones; single grain; loose; very few fine roots until 110 cm

Colour measurements: M= Moist; MC= Moist-crushed; D= Dry; DC= Dry-crushed; W= Wet.

Figure 40: Topographical map of the area surrounding profile 901. The profile is located relatively central in the Pijnven forest domain.

Figure 41: Orthophotographic view on most of the Pijnven domain with the location of profile 901 indicated by a red star.

Figure 42: At the time of the Ferraris map the Pijnven forest was heath land with active inland dunes (Ferraris, 1777).

The Pijnven bog (blue 1 in Figure 42) existed already then despite the obvious threat from the parabolic dune (blue 2) coming very close (see figure). The red star indicates more or less the location of soil profile 901.

Photo 42: View on the forest stand and the spot where the profile was studied.

Photo 42 shows a ditch present in the front wall of the profile. This ditch was invisible on the surface, otherwise the location of the profile would have avoided this disturbance of the soil profile development.

Photo 43: Close up on the humus developed on top of soil profile 901, Pijnven.

Photo 43 shows a very sharp boundary between the humus layer and to the mineral soil. The humus was classified as an Eumor.

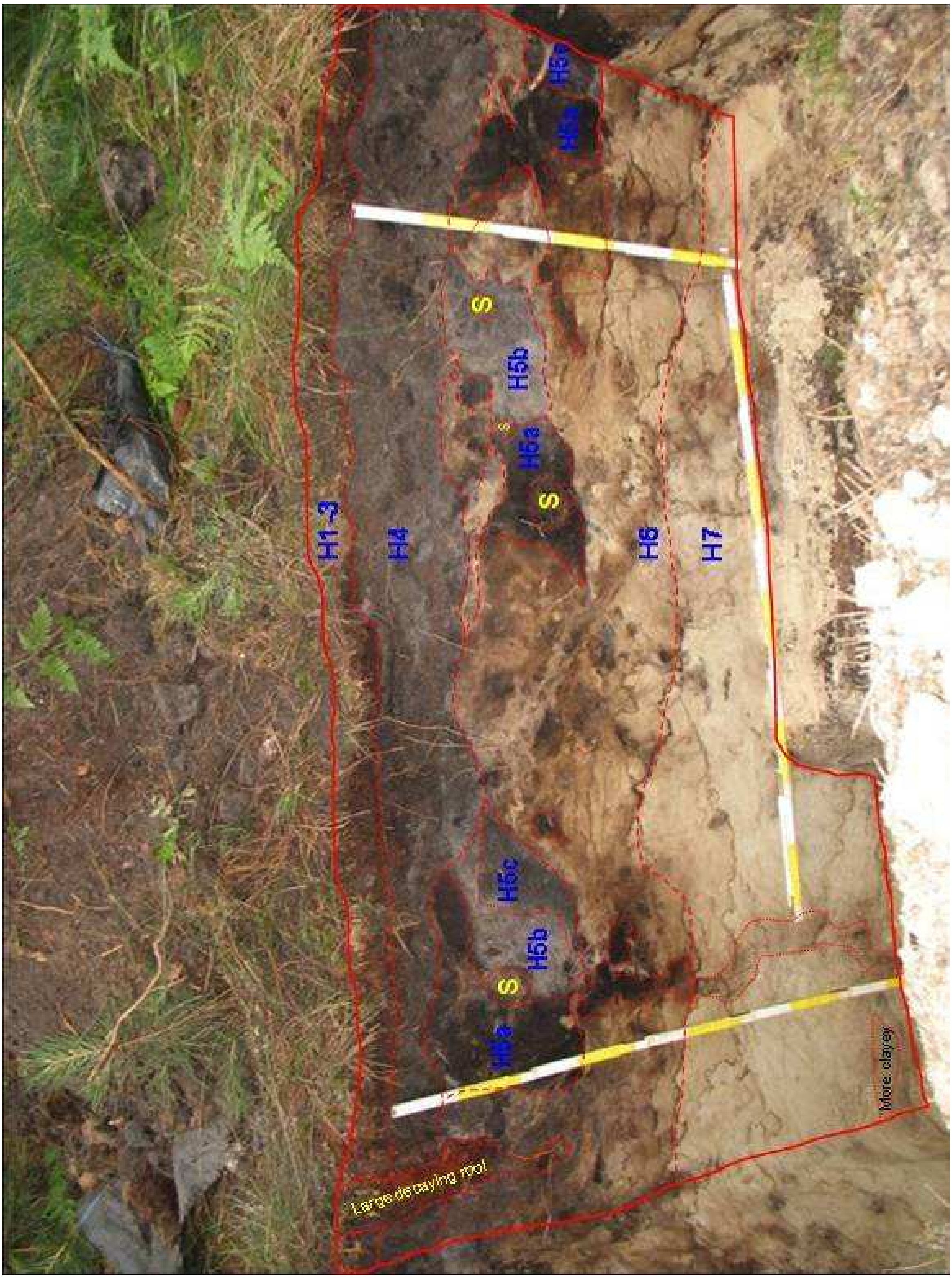

Photo 43: Soil profile 901, a soil with poorly developed horizons that in top have been deep ploughed

14.2. Analytical data

Table 31 shows a C/N ratio above 20 in the upper part of the soil. An extremely low ratio is found in H6b and H7b, which is explained by a relatively high content of nitrogen combined with an extremely low content of carbon. It is expected that the content of nitrogen will drop through leaching hereby re-establishing a C/N ratio above 12, which is normal for this kind of soils.

An extremely high content of organic carbon is observed in H5, a second sample with a high content is the best developed part of H6. The soil is very acid in the top part and acid in the subsoil.

Table 32: Analytical data for profile 901, Pijnven, Limburg, Belgium. Profile studied 26/6/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	Horizon symbols	Depth cm	Total N (Kjeldahl) Modified %	Standard %	Org. Carbon TOC %	W&B %	OM LOI %	pH H_2O 1:1	pH H_2O 1:5	pH $CaCl_2$ 1:5	Coarse frag. >2mm %-wght
1	OL	6-4									
2	OF	4-1	1.606				94		3.7	2.8	
3	OH	1-0	1.274				79		3.3	2.5	
4	A/Ep	0/5-12/20	0.183	0.160	5.95	5.5			4.0	3.3	15.3
5	Bh1	12-20	0.270	0.359	9.36	10.6			3.9	3.3	0.7
6a	Bh2	12/42-46	0.053	0.068	1.18	1.2			4.2	3.7	0.5
6b	Bh2	46-50/60	0.026	0.026	0.06	0.2			4.4	4.2	0.0
6	Bh2	best developed	0.097	0.098	2.46	1.7					0.3
6	Bh2	by-pass flow	0.038	0.026	0.40	0.5					0.1
7	C1	50/60-95/100			0.03	<0.1			4.7	4.6	0.0
7b		clay balls	0.038	0.033	0.11	<0.1			4.5	4.1	16.3
8	C2	95/100-…			0.03	<0.1			4.8	4.5	0.0

Horizon nr.	Particle size distribution (fractions in µm) 0-2 %	2-10	10-20	20-50	50-63	63-100	100-125	125-250	250-500	500-1000	1000-2000
1											
2											
3											
4	2.7	2.7	2.0	6.0	0.3	1.5	2.2	34.9	27.8	16.8	3.0
5	4.3	3.9	0.4	5.7	0.3	2.0	4.2	39.2	27.8	11.0	0.9
6a	1.8	2.6	1.3	3.5	0.2	1.9	4.7	42.2	29.7	11.3	0.8
6b	1.8	0.2	0.5	1.5	0.3	3.0	8.4	55.5	22.5	5.7	0.5
6											
6											
7	0.9	0.3	0.2	0.7	0.2	1.6	42.7		35.2	17.6	0.4
7b	15.1	9.3	1.6	5.5	0.3	1.1	25.7		23.2	15.6	2.5
8	1.1	0.6	0.1	0.9	0.2	2.1	5.0	61.1	21.8	6.3	0.7

Horizon nr.	Mg++ (by NH_4OAc, cmol(+)/kg soil')	Na+	K+	Ca++	CEC	BS %	CEC/clay	Al Dithi. Citrate %	Fe Dithi. Citrate %	Al Oxalate %	Fe Oxalate %
1											
2	1.02	<0.22	0.66	4.96	80.9	<8				0.077	0.085
3	0.94	<0.22	0.54	3.75	98.0	<5				0.234	0.233
4	0.06	<0.22	<0.13	0.10	19.3	<2					
5									0.040	0.483	0.038
6a	0.05	<0.22	<0.13	0.06	6.8	<4			0.234	0.119	0.294
6b	0.06	<0.22	<0.13	0.09	1.4	<23	<67		0.034	0.045	0.021
6									0.495	0.193	0.728
6											
7	0.05	<0.22	<0.13	0.05	0.4	<67	<32				
7b	0.06	<0.22	0.04	0.06	5.7	<5	<35		0.022	0.168	0.021
8											

Horizon nr.	Horizon symbols	Depth cm	Mg++ (by $MgSO_4$ (compulsive method), cmol(+)/kg soil)	Na+	K+	Ca++	Al+++	Fe+++	Mn++	the	Lab nr.
1	OL	6-4									JM141
2	OF	4-1	0.65	<0.09	0.63	8.03	2.72	0.18	0.198	9.09	JM142
3	OH	1-0	<0.55	<0.08	0.51	5.54	9.95	0.70	0.085	10.41	JM143
4	A/Ep	0/5-12/20	<0.24	<0.04	0.04	0.05	8.12	0.18	<0.005	0.84	JM144
5	Bh1	12-20									JM145
6a	Bh2	12/42-46	<0.12	<0.02	0.02	<0.02	2.92	0.10	<0.002	0.33	JM146
6b	Bh2	46-50/60	<0.12	<0.02	<0.01	<0.02	0.85	<0.01	<0.002	0.04	JM147
6	Bh2	best developed									JM148
6	Bh2	by-pass flow									JM149
7	C1	50/60-95/100	<0.12	<0.02	<0.01	<0.02	0.22	<0.01	<0.002	0.00	JM150
7b		clay balls	<0.12	<0.02	0.09	<0.02	3.91	<0.01	<0.002	0.04	JM151
8	C2	95/100-…									JM152

Table 31 (continued): Analytical data for profile 901, Pijnven, Limburg, Belgium. Profile studied 26/6/2006. Profile analysed 09/2006 - 02/2007.

Horizon nr.	CEC sum	CEC measured	BS by CEC-m	Acidity sum	Acidity titrated	K	Ca	Mg	Na	P	S
	cmol(+)/kg		%	cmol(+)/kg		Aqua Regia mg/kg					
1						1195	3173	424	118	605	1337
2	21.5	22.6	<41	12.2	14.7	489	1808	272	87	630	2377
3	27.2	30.5	<21	21.2	22.5	528	1242	271	75	669	2084
4	9.2	10.3	<2	9.1	11.6	684	120	335	50	209	209
5											
6a	3.4	3.7	<3	3.3	4.2	1249	263	607	85	224	85
6b	0.9	<4	~4	0.9	1.0						
6											
6											
7	0.2	<4	~4	0.2	0.4	353	88	111	36	17	15
7b	4.0	4.2	<4	3.9	4.0						
8											

Horizon nr.	Al	Cd	Cu	Fe	Mn	Cr	Pb	Ni	Zn	EC	$CaCO_3$
	Aqua Regia mg/kg									dS/m 1:5	%
1	567	1.82	7.7	322	207	1	13.9	2.7	132		
2	1784	2.59	25.9	2216	78	5	133.0	7.7	222	0.11	
3	4766	3.40	63.5	6341	61	12	875.5	12.4	355	0.12	
4	6540	0.60	1.9	4401	13	8	19.7	2.3	13	0.04	
5										0.04	
6a	7913	0.20	0.7	6159	16	14	5.7	3.2	14	0.03	
6b										0.02	
6											
6											
7	2899	<	0.3	581	3	2	1.6	1.4	10	0.02	
7b										0.03	
8										0.02	

Coarse fragments are found in most horizons in small quantities of less than 0.5%. Two exceptions are horizons H4 and H7b. H4 is the plough layer and H7b are the clay balls included in H7. The coarse fragments in H4 was described in the field as having sizes up to 28 cm diameter, which comes into the category of the boulders.

According to the profile description the content of coarse fragments remains similar throughout the horizons H4-H6. In H7-8 no stones were observed. The discrepancy between the laboratory data and the field observations concerning the content of coarse fraction illustrates the problems of sampling soils with common coarse fragments. In this case the field description states that the soil contains common gravels and stones. When the content of coarse fragments should be determined in the laboratory as a weight-% then very large samples should be taken to get a correct result. For this profile the size of the samples should be in the magnitude of 5-10 kg per horizon. When boulders are present in the field, it is practically impossible to take a representative sample to the laboratory.

The particle size distribution is relatively uniform, of coarse with the clay balls (H7b) as an exception as they contain more clay and silt. It is also noticed that in H5 there is a slight increase in the clay content. This is most probably a laboratory error. It appears that samples containing very high contents of very fine organic matter are very difficult to handle in the laboratory. It is not clear whether the problem lies in an insufficient destruction of organic matter by insufficient addition of hydrogen peroxide or whether it is because the type of organic matter, which has migrated into the Bh horizon, is of such a type that it only partly becomes destroyed by hydrogen peroxide.

The content of basic cations found in all mineral soils of this profile is very low. As for other sandy soils the nutrients are stored nearly entirely in the litter layer. The cation that is most frequently stored on the cation exchange complex is aluminium with saturations in the mineral soil ranging from 88-99%, but even in the OH horizon the saturation by aluminium is as high as 37%.

Relatively high contents of dithionite and oxalate iron are observed in the best developed parts of H6. The content is sufficient to qualify for a Spodic horizon in case that would be relevant.

The highest contents of all horizons analysed in this report on cadmium are found in the litter layer of this soil profile, but also the content of copper is high. The content of lead is the highest observed on these 10 international Level I plots with a peak of 875 mg/kg. Also the content of zinc is among the highest which might be related to the vicinity of a zinc factory. In any case the contents are far from levels found in real polluted soils.

The bulk density could only be determined in 3 horizons and shows low to medium values (1-1.5 g/cm^3). The water holding capacity is dramatic low. In H6a and 7 the water content at pF 2 is as low as 5.1-6.2% (Table 32 and Figure 43).

Table 33: The bulk density and the water holding capacity for profile 901, Pijnven.

Horizon nr.	Horizon symbols	Depth cm	Actual water content %	BDs soil g/cm3	BDFE fine earth g/cm3	Lab nr.
1	OL	6-4				JM141
2	OF	4-1				JM142
3	OH	1-0				JM143
4	A/Ep	0/5-12/20		1.05	1.04	JM144
5	Bh1	12-20				JM145
6a	Bh2	12/42-46		1.45	1.45	JM146
6b	Bh2	46-50/60				JM147
6	Bh2	best developed				JM148
6	Bh2	by-pass flow				JM149
7	C1	50/60-95/100		1.51	1.51	JM150
7b		clay balls				JM151
8	C2	95/100-...				JM152

Horizon nr.	pF 0.0	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.7	pF 3.4	pF 4.2
	----	----	----	Vol. % water	----	----	----	----
1								
2								
3								
4	49.9	46.0	32.6	19.5	17.1	16.5	17.9	13.9
5								
6a	52.5	47.8	34.0	5.1	2.8	2.3	7.4	4.2
6b								
6								
6								
7	55.6	50.5	24.4	6.2	4.8	3.6	1.8	1.0
7b								
8								

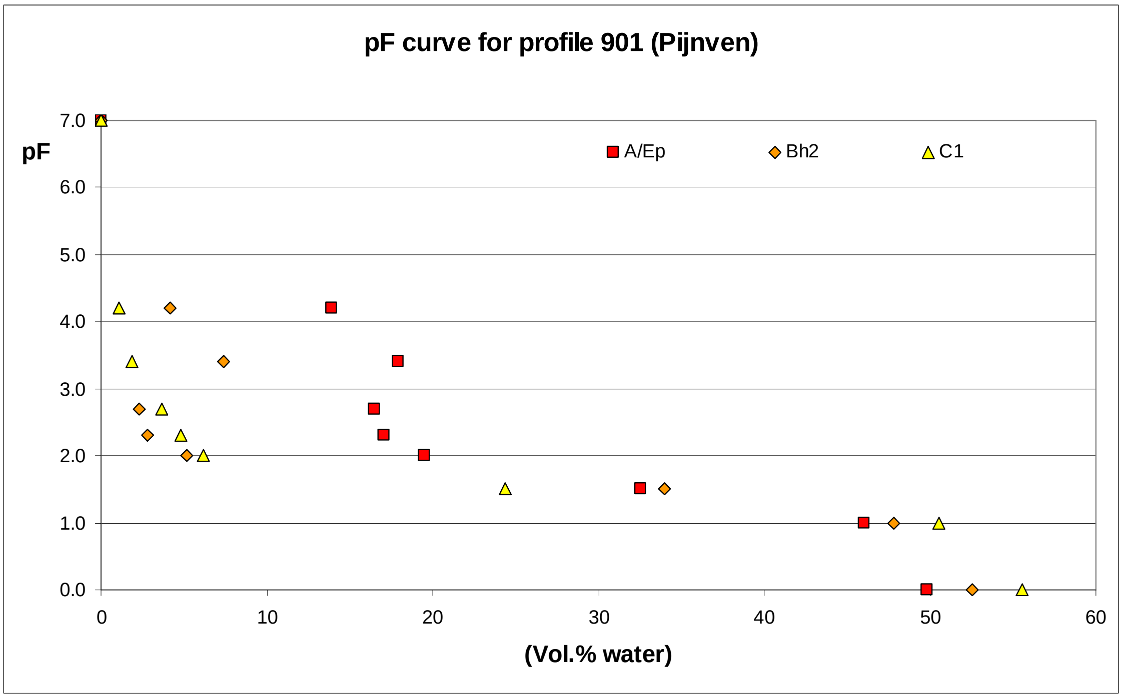

Figure 43: The water content in function of different pF values, profile 901, Pijnven

14.3. Information deduced from the Belgian Soil Map

Profile 901 is included in soil map 47W Leopoldsburg. The largest part of this map is military domain, which has been mapped separately and kept confidentially. The soil profile is located in the upper right corner of the map in a rather uniform soil landscape at least according to the applied legend. The profile is included in the map symbol t-Zbg (Figure 44). In the nearby region we find t-Zcg, t-Zdg, ZAg and X (Table 33). More to the south the map unit V is found, which is associated with the Grote Nete tributary.

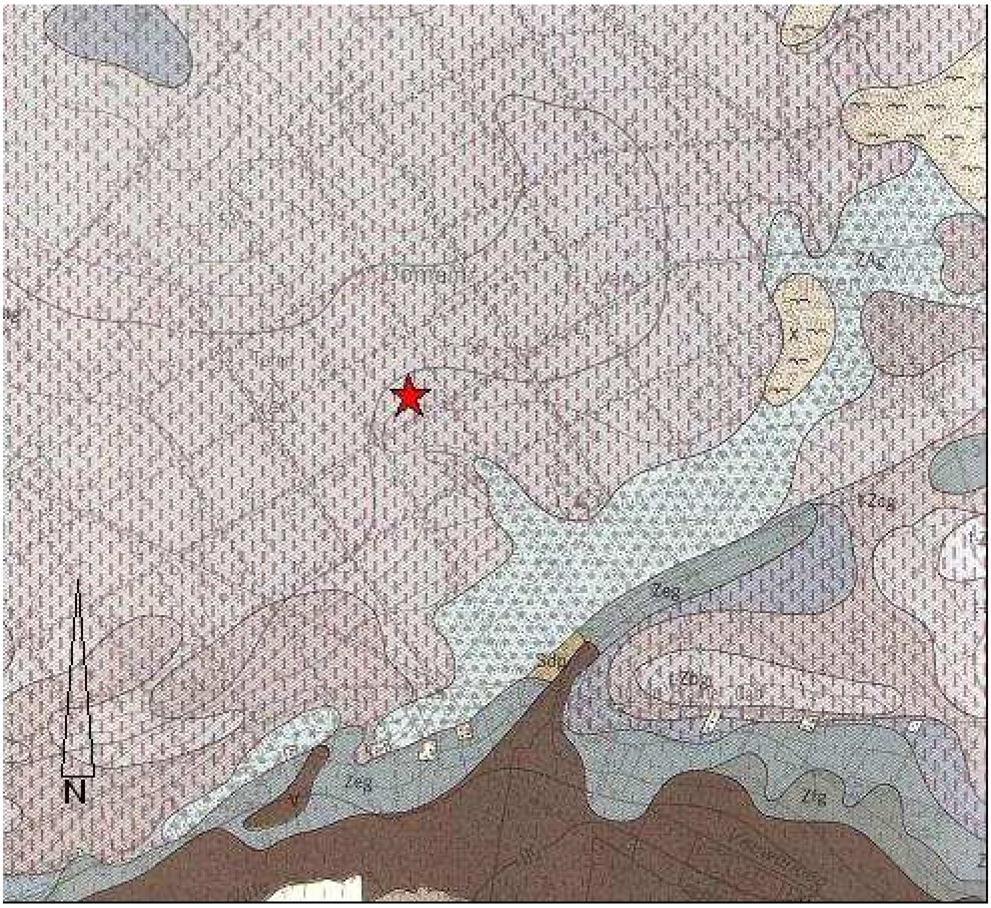

Figure 44: Detail of soil map Leopoldsburg 47W (Baeyens and Tavernier, 1969). The red star indicates the position of soil profile 901.

Table 34: Map units present in the immediate surroundings of profile 901, Pijnven (after Baeyens and Tavernier, 1975)

Map symbol	Description
t-Zbg	Dry sand soils with well developed humus and/or iron B horizon. Gravel substratum starting at shallow to moderately shallow depth (20-125 cm)
t-Zcg	Moderately dry sandy soils with well developed humus and/or iron B horizon. Gravel substratum starting at shallow to moderately shallow depth (20-125 cm).
t-Zdg	Moderate wet sandy soils with well developed humus and/or iron B horizon. Gravel substratum starting at shallow to moderately shallow depth (20-125 cm)
ZAg	Very dry to moderate wet sandy soils with well developed humus and/or iron B horizon. Fossil land dunes.
X	Land dunes still active
V	Soils with bog deposits minimum 30 cm thick and containing at least 30% organic matter.

The map unit t-Zbg where soil profile 901 has been studied is described as a dry humus or humus-iron Podzols and shows following horizon sequence: Ap, Bh, Bs and C. The groundwater is found at more than 2 m depth during the summer. Most of the domain Pijnven consists of this soil type.

14.4. Classification according to World Reference Base (2006)

Diagnostic horizon, properties, material	Present in horizon	Remarks
Albic	H7-8	Concerns C horizons
Argic	-	H7b is made up of discontinuous clay balls. They are part of the parent material and therefore they can not qualify for Argic (in presence of a lithological discontinuity the illuvial nature of the Argic horizon should be documented.
Cambic	-	H5 qualifies for all requirements except the texture.
Spodic	H5	pH is 3.93 (H_20, 1:5); OC is 9.36%; colour is 10YR2/1; no Albic horizon above; oxalate Al + ½ oxalate Fe is in for H5 0.501% (should be at least 0.5%)
Abrupt textural change	H7→H7b	Discontinuous

Most probably this profile has undergone serious erosion, whereby in the upper horizons a stone content of 15% is found, which is not present below. This can also explain the absence of soil development (e.g. podzolisation).

This soil profile will not become a Podzol although H5 is qualifying as a Spodic, because this horizon is only present in the profile as isolated pockets. These pockets are formed through a single time ploughing and is composed of H5a: the original Bh horizon, H5b: the original E horizon, and H5c: the original A horizon. As these pockets are remains of a past soil, they should not have any influence on the soil classification. With time these remains will vanish and a new Podzol will develop.

Simplified classification name

Hydrophobic Brunic Arenosol

- Hydrophobic: Although not tested in the field, most probably the soil will show hydrophobic characteristics. Evidences are the salt and pepper like mineral A horizon composed of uncoated quartz grains and fragmented organic matter, which upon drying becomes hydrophobic.
- Brunic: H6 qualifies the colour (redder hue) and depth requirements for Cambic if compared with the underlying H7. The texture requirement for Cambic is not fulfilled.
- Hypoluvic: H7b is clay fragments embedded in a sandy matrix (H7). Although a clay increase of 3% is observed between H7 and H7b, due to the very discontinuous nature of H7b Hypoluvic is not considered to be present.

Full classification name without specifiers

Hydrophobic Brunic Arenosol (Dystric)

BioSoil classification name (WRB 2006), with specifiers

Hydrophobic Hypobrunic Arenosol (Hyperdystric)

- Brunic: It is not a particular well developed B horizon, therefore Hypo is applied.

14.5. Discussion

Profile 901 is an example of a soil where the usual approach of defining horizons being more or less horizontal layers is impossible to follow. The soil is rather composed of clusters of similar history.
The soil exposes a series of events, the sequence are as follows:

1. A humus Podzol developed. This soil composed of about 10 cm greyish A horizon, about 5 cm light greyish E horizon, 12-15 cm blackish Bh horizon, and 3-5 cm of reddish brown Bhs horizon resting on top of a BC and a C horizon. [observed in preserved blocks of the original soil]
2. The soil is (deep) ploughed one single time to a depth of about 40 cm. By this action the original Podzol was broken. Today the original Podzol is still visible with the complete horizon sequence visible in large blocks, the only difference is that the blocks are tilted 90° from their original position, which corresponds to a single time ploughing. [The furrows of the deep ploughing are clearly observed on the side walls. Over the length of the side 3 furrows are observed.]
3. The soil was ploughed several times to a depth of about 15 cm, hereby a thin surface mineral horizon of a relative homogeneous colour has been developed. [referring to the lower half of H4]
4. Drainage ditches were made perpendicular to the furrows of the deep ploughing event. The depth of the observed ditches was about 45 cm. [observed on the front wall of the profile; the ditch is crossing the plough layer meaning that it is younger than the plough layer]
5. The ditches were closed relatively fast with fragments of A and C horizon material. [At the bottom of the ditch no evidences that the ditches ever worked as drainage ditches were found like sedimentation traces or layering of humus rich and poor sediment]
6. The soil is left in peace sufficiently long time to allow the development of a litter layer on top. The wavy form of the litter layers may reflect either compaction by machines (such as timber jacks) or tracks from removal of the timber itself.

That this soil is keyed out in Arenosol seems logical. The Podzol that ones existed has been unable to re-establish itself, instead a mixture of pockets and remains of human impact makes up the soil mass that has one thing in common which is the sandy texture. Another strong characteristic is the very poor fertility, which is expressed by the qualifier Hyperdystric.

On the other hand, the surveyors in 1993 did classify this soil within the group of the 'Carbic Podzols', following the classification rules of the FAO (1988) classification system. So this profile is an example where the more severe requirements of WRB-2006 to fit within the soil reference group of the Podzols, is responsible for a change of the major soil group of the Podzols (FAO, 1988) into the soil reference group of the Arenosols (WRB-2006).

15. Conclusions

The BioSoil inventory in 2006 allowed us to classify accurately the soil types met in the 10 Flemish international Level I plots, according to the recent, widely applied, system of the World Reference Base for Soil Resources.

Together with a detailed site and profile description, detailed analytical information on the horizon composition becomes now available. All this high quality information will be stored in the European Soil Database at the Institute for Environment and Sustainability of the Joint Research Centre of the European Commission.

When comparing the soil classification of these 10 plots with the classification based on the soil augering survey of 1993, WRB offered in most case a better and more detailed classification name. The Haplic Podzols (on plots N° 505, 602 and 703) received additional important qualifiers as Albic and Folic. Two previously defined Podzols did not fulfil the WRB requirement for this major soil reference group any more and end up in the group of the Arenosols and Regosols. The Gleysol in plot N° 801 also received additional useful qualifiers although the 'fluvic' qualifier would have been appropriate here. Two previously defined Alisols during the soil augering observations in 1993, moved to the major soil reference group of the Albeluvisols. It is indeed difficult to described and characterise the albeluvic tonguing in an auger observation. One profile in 1993 was erroneously classified in the group of the Arenosols. Thanks to the available textural analyses, the three profiles in Deurne fitted in the major reference groups of the Regosols and Alisols.

So the correlation between the FAO (1988) and the WRB-2006 classification system was on some plots better than on other plots. When there was a shift in the major soil groupings or reference groups, it could be attributed to 1) a change in definitions or 2) 'translation' problems between national and international classification systems or 3) detailed analytical results which were not available at the first inventory.

The BioSoil project was furthermore an important demonstration project for the application of WRB-2006. The IUSS WRB Working Group will learn from the experience gained in Flanders, and in the other participating countries, to further update and improve this worldwide classification system.

This document can be used as a reference document for the scientists occupied by the crown assessments or other research activities on the Level I network.

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18. List of Figures

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