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MANUAL

on

methods and criteria for harmonized sampling, assessment,
monitoring and analysis of the effects of air pollution on forests

Part X

Sampling and Analysis of Soil

(Annex II - Soil profile description and classification)

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Annex II - Soil profile description and classification

1 Introduction

On each ICP Forests plot (Level I and Level II) a pedological profile characterisation has be done once at the plot installation (see pg. 8 Manual Part X, (§ 4.1.1). For this, the Manual follows the rules of the most recent edition of the World Reference Base of Soil Resources. A minimum set of variables should be reported making use of the PRF and PFH form in the S1 (Level I) or SO (Level II) survey. For the description of the soil profile and the horizons the IUSS Working Group on WRB (2022) field guide (8 Annex I) should be followed to a maximal extent. However, this Annex provides 1) **additional** information, not provided in WRB 2022 and 2) information on those **parameters that deviate** from the IUSS Working Group on WRB (2022) guidelines and rules. Furthermore, this Annex II contains the updated tables of the ICP Forests online documentation of the PRF (Level I, Level II) and PFH forms (Level I, Level II).

2 Recommendations for locating and describing a soil profile

Related data field in the PRF form: date_profile_desc, latitude, longitude, elevation

2.1.1 Location of the soil profile

The location of the soil profile should be as representative for the plot as possible. Obviously only surface characteristics can help us in this search. Factors of importance can be:

- Composition of ground vegetation, e.g. if most of the plot hosts no ground vegetation do not locate the profile where vegetation is present
- Composition of tree stand; dig the profile under the canopy of dominant tree species.
- Avoid areas of strong human influence, such as ditches, earth banks, forest roads, tracks from tree harvesting machines…
- Avoid micro-lows and micro-highs, as they will allow more or less litter to accumulate, which will have an influence on the biological activity and hydrology.
- On plots with steeper slopes, it is important to locate the profile as representative as possible with respect to the general slope inclination. If the general slope is concave or convex, then try to locate the profile at the level of the plot centre with respect to the slope (meaning in the zone immediate outside the plot to the left or the right of this plot centre: not down- or upslope).
- Other factors such as surface stoniness, rock outcrop, different land-use practice etc. should also be taken into consideration so that the profile location is as representative as possible.

2.1.2 Orientation of the soil profile

Factors to take into consideration are:

- If the slope inclination is such that it will have an important impact on the hydrology, then the profile should be oriented with its long axe in the slope direction.

- If the slope inclination is not important, the profile is oriented in such a way that by the time the profile is to be studied the light should be equally distributed over the complete profile wall (e.g. if you start to dig at 10 AM and you estimate that it takes 2h to dig the profile, and 30min to clean it for taking photos, then orient the profile towards SSW (180-200°). By the time you can take photos the profile will have a perfect angle towards the sun. A wall that is partly shaded partly with sunshine is impossible to describe optimally, and no quality photos can be produced.
- If the slope and light is not a problem, then other factors can help with the orientation of the profile, such as microtopography, vegetation, etc. For example, if the plot is characterised by drainage ditches, orienting the profile with its long axis perpendicular to the ditch will result in a profile where on the side walls it will be possible to observe the changes from a wetter soil closest to the ditch towards a drier soil between the ditches.

2.1.3 Observations to be made while digging the profile

If the field work is organised in such a way that the person that will do the profile description will be present when the profile is dug, it is advisable to make some first observations during this process. Following aspects of a standard profile description can by substantially improved if already considered during the profile digging, simply because the observations are made not only based on a two dimensional profile wall, but based on about one cubic metre of soil that is removed:

- The rock fragments: description of the abundance, size, shape, and type is considerable improved, and special features such as presence/absence of pendants/cappings on the stones are better observed.
- Soil structure, especially type and degree of development
- Cutanic features, especially if the quantity is low working in a three dimension will improve the chance to observe such features
- Presence of cementations and compactions will undoubtedly be discovered when the profile is worked with the spade, shovel and pickaxe.
- If carbonate is present, observing if at least part of the carbonate is secondary will be easier.
- Quantification and size estimates of roots, as well as the total root depth is more accurately observed

2.1.4 Observations in three dimensions

1. A standard profile is typically 80-100 cm wide, 180-200 cm long and should have a depth of 200 cm. The wideness and length can be reduced if e.g. the soil is very stony, but be careful not to diminish the profile beyond the size where proper use of spade, shovel, pickaxe is restricted. The profile depth can be limited by a series of factors, such as:
    - The groundwater table. If the permeability of the soil is low, digging below the groundwater table is possible and even soil sampling and/or making a few observations such as colour, reductomorphic properties, … is possible. Remember to measure the actual groundwater depth.
    - Bedrock, either continuous or discontinuous rock that prevents further digging
    - Cementations of any kind, For example a Petrocalcic, Petroduric, Petrogypsic, Petroplinthic or Pisoplinthic cemented horizon which makes any further digging impossible.

- Parent material. If the C horizon material is reached at a shallower depth than 200 cm, further digging can be stopped. It is though recommended to continue 20-50 cm to control that it indeed is the C-horizon that has been reached.

When the profile in its full length has reach a depth of about 100-120 cm, further digging is restricted to the 80-100 cm of the profile closest to the front wall. This creates a soil pit with 2 or more steps.

After digging the profile, it is essential to clean the profile walls.

- This is done by e.g. a knife, trowel, or another scraping tool with an metal blade, make sure that the metal blade has rounded edges to avoid sharp scraping lines on the profile wall.
- While the profile is cleaned, the soil is carefully observed, with respect to colours, presence absence of roots, biogalleries, stones and other characteristics that might be important to outline the horizons.
- Take the first round of photos. Of the profile, details of the profile, and the surrounding landscape. Hold the camera perpendicularly to the profile wall. Avoid any inclination. Also take at least one picture of the surrounding terrain and vegetation e.g, the tree canopy.
- Draw on the profile wall with the knife the horizon boundaries. The most important feature to delineate horizons from each other is change of colour. Other feature that can be used to differentiate genetic horizons from each other are a relatively sharp change over (vertical) distance of mottles, texture, coarse fragments, structure, porosity, cementation, compaction, nodules, roots or carbonates.
- A second round of photos is taken of the profile with and without the horizon boundaries indicated, and of particular details such as mottles, involutions, biogalleries, disturbances etc.

If a soil is composed of well-developed relatively uniform horizons, focussing on the front wall for the profile description is usually sufficient. If on the other hand the profile is more irregular and/or the horizons are less developed, it might be necessary to study also the side walls. This should appear from the profile description. For example the horizon depths in soil profiles located on a strong slope should be measured perpendicular to the surface, which is easiest on the side wall.

For certain pedological features, it might be useful to study them on a horizontal section. This is for example possible while digging the profile, or when the first or second stair has been made at the correct depth. If necessary, a new sub-profile is dug on the sidewall to the depth(s) where a horizontal section is needed.

3 Field equipment

Equipment for profile description:	**Number**	**Further information**
Spade, pickaxe	1	
Shovel	2	
Bucket	1	
Scraper	1	Make the corners rounded to avoid sharp lines on the cleaned profile wall
Trowel	1	Sharpen the edges to allow a better cutting in the soil
Knife	1	The blade should be straight (e.g. to cut bulk density samples straight) and as long as possible (recommended is 15-20 cm)
Field umbrella	1	To shade for sun and rain

Pruner or horticulture sheer	1	To cut roots
Small painting brush	optional	To highlight certain special features e.g. slickensides, stones, etc.
Munsell Colour Chart	1	Try to avoid dirt on the colour chips
Folding ruler or measuring tape	2	Two coloured ones are preferred
Note book	1	Large enough e.g. A5 format, with squared lines on the paper to facility profile drawings
Writing pen/pencil	2	
Marker pen	2	For sample labelling, black colours are more resistant to sun light
Sample labels	sufficient	
Hand lens	1	Magnifications x10 (4 +6 or 2 + 8)
Soil thermometer	optional	Especially if the soil at or below 0°C
Penetration rod	1	Required if the soil is compacted, cemented or is stony
Clinometer or Abney-level	1	To measure slope inclinations
GPS system	1	Measuring coordinates of key points on the plot
Compass	1	For orientation of e.g. slope direction
Auger handle	1	
Auger heads	selection	Selection in accordance to soil type, see table below
Extension rods	1	With one extension a depth of 225 cm can be reach
Photo camera and tripod	1	
Water bottle	1	
Water sprayer	1	
For sampling	**Number**	**Further information**
Sampling tray	optional	
Sample recipients	sufficient	Quality bags (plastic, cloth..) or boxes
Sample labels	sufficient	
Sample frame	1 - 3	To sample the organic layer
For pF and bulk density	**Number**	**Further information**
Bulk density cylinders (volume between 100 cm^3 and 250 cm^3) and lids	sufficient	Take care not to destroy the cutting edge of the ring while inserting it into the soil. See SA04 in Annex I.
Ring holder	optional	Needed if the soil is hard (e.g. due to dryness and/or a high clay content)
Impact absorbing hammer	1	Eventually a geological hammer if fieldwork is done in mountainous regions
Wood piece	1	To distribute the hammer impact equally
Hammering head	optional	For very hard soils, to be used with the guide cylinder
Cylinder guide	optional	
Small iron saw	1	To cut the edges of the sampling rings
Liquids:	**Number**	**Further information**
Distilled water*	±100 cl	To test moist colours; testing for water repellence
Concentrated H_2O_2*	±100 cl	Reacts to manganese (charcoal and organic matter not)
10% HCl*	±100 cl	Reacts to carbonates
α, α dipyridyl*	±100 cl	Reddish colour reaction if Fe^{2+} is present

* The liquids are by preference stored in bottles, which allow drop wise application (like eye drops). If this is not possible, bring along plastic pipettes for careful application.

Soil augers:

Soil texture	Moisture condition	Type of Edelman augers	Riverside auger	Gouge auger
	wet	Sand	-	-
Sandy	moist	Combi, sand	(+)	+
	dry	Sand	-	(+)
	wet	Combi	-	+
Loamy/silty	moist	Combi	-	+
	dry	-	+	-
	wet	Clay	-	+
Clayey	moist	Clay	-	+
	dry	-	+	-
	wet	Gravel	-	-
Stony	moist	Gravel	-	-
	dry	-	+	-
Frozen soil		(Gravel)	(+)	-

"-" : not suitable
"(+)" : possibly suitable
"+" : suitable (recommended)

<u>Clay-auger:</u> thin blades, good for clayey and/ sticky soils when moist and wet

<u>Combi-auger:</u> all round auger best for medium textured soils when moist and wet

<u>Sand-auger:</u> has wide blades, so the sand stays in the auger even if the soil is relatively dry

<u>Gravel-auger:</u> with two cutting blades at the end that can drill and remove small stones

<u>Riverside-auger:</u> closed with drilling blades, the only auger that can be used in dry loamy or dry clayey soils. It should be avoided when these soils are moist or wet! Sometimes also useful in frozen soils

<u>Gouge-auger:</u> for non-stony soils preferentially moist or wet. It can take undisturbed samples. Mode length variable, mostly 50 to 100 cm long.

For the sampling of the organic layer <u>a frame of 25 by 25 cm</u> is recommended, but alternatives with a minimum total surface of 500 cm^2 are acceptable. For mor humus, an auger with a diameter of 8 cm can be used.

4 Completing the soil profile description form (PRF)

Following variables should be reported: *!Sequence; country; plot;* ***profile_pit****;* ***date_profile_desc****; latitude; longitude; elevation; soil_group; qualifier_1; specifier_1; qualifier_2; specifier_2; qualifier_3; specifier_3; qualifier_4; specifier_4; qualifier_5; specifier_5; qualifier_6; specifier_6; classification_full_name; diagnostic_1; diagnostic_depth_1; diagnostic_2; diagnostic_depth_2; diagnostic_3; diagnostic_depth_3; diagnostic_4; diagnostic_depth_4; diagnostic_5; diagnostic_depth_5; diagnostic_6; diagnostic_depth_6; diagnostic_7; diagnostic_depth_7; diagnostic_8; diagnostic_depth_8; diagnostic_9; diagnostic_depth_9; diagnostic_10; diagnostic_depth_10; WRB_publication; parent_material_1; parent_material_2; ground_water_highest; ground_water_lowest; water_table; water; humus; eff_soil_depth; other_observations*

4.1 Reference Soil Group (RSG)

Data field in the PRF form: soil_group (M)

When describing and classifying a soil profile, the most recent system of WRB should be used. In 2025, this is the 4th Edition of the World Reference Base for Soil Resources by the IUSS Working Group on WRB (2022) including 32 Reference Soil Groups (RSGs).

A list of the RSG accepted by the ICP Forests database is provided below. For definitions, consult the relevant WRB publication PRF data field 43, explanatory item 126 (see https://icp-forests.org/documentation/Dictionaries/d_wrb_pub.html).

CODE	DESCRIPTION	FROM_ YEAR	TO_ YEAR
06ar	WRB 2006, Arabic version	1984	
06en	World Reference Base for Soil Resources, World Soil Resources Reports N° 103. FAO, Rome. - Final Version 2006	1984	
06es	WRB 2006, Spanish version	1984	
06pl	WRB 2006, Polish version	1984	
06ru	WRB 2006, Russian version	1984	
06sk	WRB 2006, Slovak version	1984	
06tr	WRB 2006, Update 2007, Turkish version	1984	
07en	World Reference Base for Soil Resources, World Soil Resources Reports N° 103. FAO, Rome - first update 2007	1984	
07ge	WRB German version 2007 provided by the Federal Institute for Geosciences and Natural Resources (BGR)	1984	
14en	WRB 2014, Version 2014	1984	
15en	WRB 2014, Update 2015	1984	
15es	WRB Spanish version 2014, update 2015	1984	
15fr	WRB French version 2014, update 2015	1984	
15ru	WRB Russian version 2014, update 2015	1984	
22en	IUSS Working Group on WRB, 2022, 4th Edition	1984	
98en	World Reference Base for Soil Resources, World Soil Resources Reports N° 84. FAO, Rome.	1984	
FAO88	Revised Legend of the FAO - UNESCO Soil Map of the World. World Soil Resources Reports N° 60. FAO, Rome.	1984	

CODE	DESCRIPTION	FROM_ YEAR	TO_ YEAR	FAO 1988	WRB 1998	WRB 06/07	WRB 14/15	WRB 2022
AB	Albeluvisols	1984		0	1	1	0	0
AC	Acrisols	1984		1	1	1	1	1
AL	Alisols	1984		1	1	1	1	1
AN	Andosols	1984		1	1	1	1	1
AR	Arenosols	1984		1	1	1	1	1
AT	Anthrosols	1984		1	1	1	1	1
CH	Chernozems	1984		1	1	1	1	1
CL	Calcisols	1984		1	1	1	1	1
CM	Cambisols	1984		1	1	1	1	1
CR	Cryosols	1984		0	1	1	1	1
DU	Durisols	1984		0	1	1	1	1
FL	Fluvisols	1984		1	1	1	1	1

FR	Ferralsols	1984		1	1	1	1	1
GL	Gleysols	1984		1	1	1	1	1
GR	Greyzems	1984		1	0	0	0	0
GY	Gypsisols	1984		1	1	1	1	1
HS	Histosols	1984		1	1	1	1	1
KS	Kastanozems	1984		1	1	1	1	1
LP	Leptosols	1984		1	1	1	1	1
LV	Luvisols	1984		1	1	1	1	1
LX	Lixisols	1984		1	1	1	1	1
NT	Nitisols	1984		1	1	1	1	1
PD	Podzoluvisols	1984		1	0	0	0	0
PH	Phaeozems	1984		0	1	1	1	1
PL	Planosols	1984		1	1	1	1	1
PT	Plinthosols	1984		1	1	1	1	1
PZ	Podzols	1984		1	1	1	1	1
RG	Regosols	1984		1	1	1	1	1
RT	Retisols	1984		0	0	0	1	1
SC	Solonchaks	1984		1	1	1	1	1
SN	Solonetz	1984		1	1	1	1	1
ST	Stagnosols	1984		0	0	1	1	1
TC	Technosols	1984		0	0	1	1	1
UM	Umbrisols	1984		0	1	1	1	1
VR	Vertisols	1984		1	1	1	1	1

4.2 Qualifiers and specifiers

Data fields in the PRF form: qualifier_1 till 6, specifier_1 till 6

At the second level, the WRG RSG is combined with a set of principal and supplementary qualifiers. The PRF file allows the reporting of the codes of up to 6 qualifiers (with their specifiers – if relevant) where 'qualifier_1' is the most important principal qualifier, 'qualifier_2' the second most important qualifier etc. Priority rules as outlined in the most recent edition of WRB should be followed.

The list of the qualifiers and specifiers accepted by the ICP Forests database is provided in the online documentation (see table below). For definitions, consult the concerning edition of WRB.

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR	FAO_1988	WRB_1998	WRB_2006_2007	WRB_2014_2015	WRB_2022
a	Andic in GL, Aric in AT, Albic in all other RSGs	1984		1	0	0	0	0
aa	Aluandic	1984		0	0	1	1	1
ab	Albic	1984		0	1	1	1	1
AB	Albeluvisolic	1984		0	0	1	0	0
abg	Glossalbic	1984		0	1	0	0	0
abh	Hyperalbic	1984		0	1	0	0	0
ac	Acric	1984		0	1	1	1	1
AC	Acrisolic	1984		0	0	1	0	0
ad	Aridic Arenicolic(WRB 2022)	1984		0	1	1	1	1
ae	Aceric	1984		0	1	1	1	1

ah	Anthropic (WRB 1998) /// Archaic (WRB 2014, 2015, 2022)	1984		0	1	0	1	1
ai	Aric	1984		0	1	1	1	1
aj	Areninovic	1984		0	0	0	1	1
ak	Anthric	1984		0	0	0	1	1
al	Alic	1984		0	1	1	1	1
AL	Alisolic	1984		0	0	1	0	0
am	Anthric (WRB 1998, 2006,2007) /// Anthromollic (WRB 2014, 2015, 2022)	1984		0	1	1	1	1
an	Andic	1984		0	1	1	1	1
AN	Andosolic	1984		0	0	1	0	0
ana	Aluandic	1984		0	1	0	0	0
ans	Silandic	1984		0	1	0	0	0
ao	Acroxic	1984		0	1	1	1	1
ap	Abruptic	1984		0	1	1	1	1
aq	Anthraquic	1984		0	1	1	1	1
ar	Arenic	1984		0	1	1	1	1
AR	Arenosolic	1984		0	0	1	0	0
as	Argisodic	1984		0	0	0	1	1
at	Anthrotoxic Activic (WRB 2022)	1984		0	0	0	1	1
AT	Anthrosolic	1984		0	0	1	0	0
au	Alumic	1984		0	1	1	0	0
aw	Anthroumbric	1984		0	0	0	1	1
ax	Alcalic	1984		0	1	1	1	1
ay	Aeolic	1984		0	0	0	1	1
az	Arzic	1984		0	1	1	1	1
b	Cambic	1984		1	0	0	0	0
ba	Thaptantic	1984		0	0	1	0	0
bc	Biocrustic	2022		0	0	0	0	1
br	Brunic	1984		0	0	1	1	1
bv	Thaptovitric	1984		0	0	1	0	0
c	Carbic in PZ, Cumulic in AT, Calcaric in all other RSGs	1984		1	0	0	0	0
ca	Calcaric	1984		0	1	1	1	1
cb	Carbic	1984		0	1	1	1	1
cc	Calcic	1984		0	1	1	1	1
cch	Hypercalcic	1984		0	1	0	0	0
cco	Orthicalcic	1984		0	1	0	0	0
ccw	Hypocalcic	1984		0	1	0	0	0
cd	Cordic			0	0	0	0	1
ce	Clayic	1984		0	0	1	1	1
cf	Calcifractic	1984		0	0	0	1	1
ch	Chernic	1984		0	1	0	1	1
CH	Chernozemic	1984		0	0	1	0	
cj	Clayinovic	1984		0	0	0	1	1
cl	Chloridic	1984		0	1	1	1	1
CL	Calcisolic	1984		0	0	1	0	0
cm	Cambic	1984		0	0	1	1	1

CM	Cambisolic	1984		0	0	1	0	0
cn	Carbonatic	1984		0	1	1	1	1
co	Colluvic Cohesic (WRB 2022)	1984		0	0	1	1	1
cp	Capillaric	1984		0	0	0	1	1
cq	Claric	1984		0	0	0	0	1
cr	Chromic	1984		0	1	1	1	1
CR	Cryosolic	1984		0	0	1	0	0
cs	Coarcic	1984		0	0	0	0	1
ct	Cutanic	1984		0	1	1	1	1
cu	Columnic	1984		0	0	0	1	1
cx	Carbonic	1984		0	0	0	1	1
cy	Cryic	1984		0	1	1	1	1
d	Dystric	1984		1	0	0	0	1
df	Differentic	1984		0	0	0	1	1
dh	Profundihumic	1984		0	0	0	1	1
dn	Densic	1984		0	1	1	1	1
do	Dolomitic	1984		0	0	0	1	1
ds	Dorsic	1984		0	0	0	0	1
dr	Drainic	1984		0	0	1	1	1
du	Duric	1984		0	1	1	1	1
DU	Durisolic	1984		0	0	1	0	0
dy	Dystric	1984		0	1	1	1	1
dye	Epidystric	1984		0	1	0	0	0
dyh	Hyperdystric	1984		0	1	0	0	0
dyo	Orthidystric	1984		0	1	0	0	0
e	Eutric	1984		1	0	0	0	0
ea	Episalic	1984		0	0	1	0	0
ec	Escalic	1984		0	0	1	1	1
ed	Epidystric Endic (WRB 2022)	1984		0	0	1	0	1
ee	Epieutric	1984		0	0	1	0	0
ek	Ekranic	1984		0	0	1	1	1
el	Epileptic	1984		0	0	1	0	0
ep	Epic	1984		0	0	0	0	1
es	Eutrisilic (WRB 1998) Eutrosilic (WRB 06/07, 104/15, 2022)	1984		0	1	1	1	1
et	Entic	1984		0	1	1	1	1
eu	Eutric	1984		0	1	1	1	1
euh	Hypereutric	1984		0	1	0	0	0
eun	Endoeutric	1984		0	1	0	0	0
euo	Orthieutric	1984		0	1	0	0	0
ev	Evapocrustic	1984		0	0	0	1	1
f	Fibric in HS, Fimic in AT, Ferric in all other RSGs	1984		1	0	0	0	0
fa	Fractiplinthic	1984		0	0	1	0	0
fc	Fractic	1984		0	0	0	1	1
fe	Ferritic	1984		0	0	0	1	1
fg	Fragic	1984		0	1	1	1	
fi	Fibric	1984		0	1	1	1	1
fl	Ferralic	1984		0	1	1	1	1
FL	Fluvisolic	1984		0	0	1	0	0

flh	Hyperferralic	1984		0	1	0	0	0
flw	Hypoferralic	1984		0	1	0	0	0
fo	Folic	1984		0	1	1	1	1
fp	Fractipetric	1984		0	0	1	0	0
fr	Ferric	1984		0	1	1	1	1
FR	Ferralsolic	1984		0	0	1	0	0
frh	Hyperferric	1984		0	1	0	0	0
ft	Floatic	1984		0	0	1	1	1
fu	Fulvic	1984		0	1	1	1	0
fv	Fluvic	1984		0	1	1	1	1
g	Geric in FR, Gleyic in all other RSGs	1984		1	0	0	0	0
ga	Garbic	1984		0	1	1	1	1
gb	Glossialbic	1984		0	0	1	0	0
gc	Glacic	1984		0	1	1	1	1
ge	Gelic	1984		0	1	1	1	1
gf	Gypsifractic (WRB 2014/15) Gypsofractic (WRB 2022)	1984		0	0	0	1	1
gg	Gilgaic	1984		0	0	0	1	1
gi	Gibbsic	1984		0	1	1	1	1
gl	Gleyic	1984		0	1	1	1	1
GL	Gleysolic	1984		0	0	1	0	0
gln	Endogleyic	1984		0	1	0	0	0
glp	Epigleyic	1984		0	1	0	0	0
gm	Grumic	1984		0	1	1	1	1
go	Geoabruptic	1984		0	0	0	1	1
gp	Gypsiric	1984		0	1	1	1	1
gr	Geric	1984		0	1	1	1	1
gs	Glossic	1984		0	1	1	1	1
gsm	Molliglossic	1984		0	1	0	0	0
gsu	Umbriglossic	1984		0	1	0	0	0
gt	Gelistagnic	1984		0	1	1	1	1
gy	Gypsic	1984		0	1	1	1	1
GY	Gypsisolic	1984		0	0	1	0	0
gyh	Hypergypsic	1984		0	1	0	0	0
gyw	Hypogypsic	1984		0	1	0	0	0
gz	Greyic (WRB 1998 and 2006, 2007) /// Greyzemic (WRB 2014, 2015)	1984		0	1	1	1	1
h	Humic in CM, Haplic in all other RSGs	1984		1	0	0	0	0
ha	Haplic	1984		0	1	1	1	1
hb	Hyperalbic *	1984		0	0	1	0	0
hc	Hypercalcic	1984		0	0	1	0	0
hd	Hyperdystric	1984		0	0	1	0	0
he	Hypereutric	1984		0	0	1	0	0
hf	Hydrophobic	1984		0	0	1	1	1
hg	Hydragric	1984		0	1	1	1	1
hi	Histic	1984		0	1	1	1	1
hib	Thaptohistic	1984		0	1	0	0	0
hif	Fibrihistic	1984		0	1	0	0	0

his	Saprihistic	1984		0	1	0	0	0
hk	Hyperskeletic	1984		0	1	1	0	0
hl	Hyperalic	1984		0	0	1	0	0
hm	Hemic	1984		0	0	1	1	1
ho	Hyperochric	1984		0	0	1	0	0
hp	Hypergypsic	1984		0	0	1	0	0
hs	Hypersalic	1984		0	0	1	0	0
HS	Histosolic	1984		0	0	1	0	0
ht	Hortic	1984		0	1	1	1	1
hu	Humic	1984		0	1	1	1	1
hum	Mollihumic	1984		0	1	0	0	0
huu	Umbrihumic	1984		0	1	0	0	0
hy	Hydric	1984		0	1	1	1	1
i	Gelic	1984		1	0	0	0	0
ia	Infraandic	1984		0	0	0	1	1
ic	Inclinic	1984		0	0	0	1	1
il	Isolatic	1984		0	0	0	1	1
im	Immissic	1984		0	0	0	1	1
ip	Isopteric	1984		0	0	0	0	1
ir	Irragric	1984		0	1	1	1	1
is	Infraspodic	1984		0	0	0	1	1
iw	inclinistagnic	1984		0	0	0	0	1
iy	Inclinigleyic	1984		0	0	0	0	1
j	Stagnic	1984		1	0	0	0	0
ja	Hyperartefactic	1984		0	0	0	1	1
jb	Hypergarbic	1984		0	0	0	0	1
jc	Hypercalcic	1984		0	0	0	1	1
jd	Hyperdystric	1984		0	0	0	1	1
je	Hypereutric	1984		0	0	0	1	1
jf	Hyperferritic	1984		0	0	0	1	1
jg	Hypergypsic	1984		0	0	0	1	1
jh	Hyperhumic	1984		0	0	0	1	1
ji	Hyperthionic	1984		0	0	0	1	1
jj	Hyperspolic	1984		0	0	0	0	1
jk	Hyperskeletic (WRB 14/15) Ejectiskeletic (WRB 2022)	1984		0	0	0	1	1
jl	Hyperalic	1984		0	0	0	1	1
jm	Hypermagnesic	1984		0	0	0	1	1
jn	Hypernatric	1984		0	0	0	1	1
jo	Hyperorganic	1984		0	0	0	1	1
jp	Hyperspodic	1984		0	0	0	1	1
jq	Hypergeric	1984		0	0	0	0	1
jr	Hypersideralic	1984		0	0	0	1	1
js	Hypersulfidic	1984		0	0	0	1	1
jt	Hypertechnic	1984		0	0	0	1	1
ju	Hyperduric	1984		0	0	0	1	1
jx	Hyperurbic	1984		0	0	0	0	1
jy	Hyperhydragic	1984		0	0	0	1	1
jz	Hypersalic	1984		0	0	0	1	1
k	Rendzic in LP, Calcic in all other RSGs	1984		1	0	0	0	0

ka	Kalaic	1984		0	0	0	0	1
kf	Akrofluvic	1984		0	0	0	1	1
kh	Skeletohistic	1984		0	0	0	0	1
kk	Akroskeletic	1984		0	0	0	1	1
km	Akromineralic	1984		0	0	0	1	1
ko	Skeletofolic	1984		0	0	0	0	1
KS	Kastanozemic	1984		0	0	1	0	0
kt	Skeletotransportic	1984		0	0	0	0	1
l	Folic in HS, Luvic in all other RSGs	1984		1	0	0	0	0
la	Laxic	1984		0	0	1	1	1
lc	Linic	1984		0	0	1	1	1
ld	Lapiadic	1984		0	0	0	1	1
le	Leptic	1984		0	1	1	1	1
len	Endoleptic	1984		0	1	0	0	0
lep	Epileptic	1984		0	1	0	0	0
lg	Lignic	1984		0	0	1	1	1
lh	Litholinic	1984		0	0	0	0	1
li	Lithic	1984		0	1	1	1	1
lip	Paralithic	1984		0	1	0	0	0
lj	Loaminovic	1984		0	0	0	1	1
ll	Lamellic	1984		0	1	1	1	1
lm	Limnic	1984		0	0	1	1	1
ln	Limonic	1984		0	0	0	0	1
lo	Loamic	1984		0	0	0	1	1
LP	Leptosolic	1984		0	0	1	0	0
lv	Luvic	1984		0	1	1	1	1
LV	Luvisolic	1984		0	0	1	0	0
lvw	Hypoluvic	1984		0	1	0	0	0
lx	Lixic	1984		0	1	1	1	1
LX	Lixisolic	1984		0	0	1	0	0
m	Mollic	1984		1	0	0	0	0
mc	Mochipic	1984		0	0	0	0	1
me	Melanic	1984		0	1	0	0	0
mf	Manganiferric	1984		0	0	1	1	1
mg	Magnesic	1984		0	1	1	1	1
mh	Murshic	1984		0	0	0	1	1
mi	Molliglossic (WRB 2006, 2007) /// Mineralic (WRB 2014, 2015, 2022)	1984		0	0	1	1	1
ml	Melanic	1984		0	0	1	1	0
mm	Mulmic	1984		0	0	0	0	1
mo	Mollic	1984		0	1	1	1	1
ms	Mesotrophic	1984		0	1	1	1	0
mu	Muusic	1984		0	0	0	1	1
mw	Mawic	1984		0	0	0	1	1
mz	Mazic	1984		0	1	1	1	1
n	Sodic	1984		1	0	0	0	0
na	Natric	1984		0	1	1	1	1
nb	Neobrunic	1984		0	0	0	0	1
nc	Neocambic	1984		0	0	0	1	1
nd	Endoduric	1984		0	0	1	0	0

ne	Endoeutric (WRB 2006, 2007) /// Nechic (WRB 2014, 2015, 2022)	1984		0	0	1	1	1
nf	Endofluvic	1984		0	0	1	0	0
ng	Endogleyic (WRB 2006, 2007) /// Nudiargic (WRB 2014, 2015, 2022)	1984		0	0	1	1	1
ni	Nitic	1984		0	1	1	1	1
nl	Endoleptic	1984		0	0	1	1	1
nn	Nudinatric	1984		0	0	0	1	1
np	Nudipetric	1984		0	0	0	1	1
nr	Naramic	1984		0	0	0	0	1
ns	Endosalic	1984		0	0	1	0	0
nt	Nudilithic	1984		0	0	1	1	1
NT	Nitisolic	1984		0	0	1	0	0
nua	Nudiargic	1984		0	0	1	0	0
nv	Novic	1984		0	0	1	1	1
ny	Endodystric (WRB 2006, 2007) /// Nudiyermic (WRB 2014, 2015)	1984		0	0	1	1	1
o	Ferralic	1984		1	0	0	0	0
oa	Oxyaquic	1984		0	1	1	1	1
oc	Ornithic	1984		0	0	1	1	1
od	Orthodystric	1984		0	0	0	1	1
oe	Orthoeutric	1984		0	0	0	1	1
of	Orthofluvic	1984		0	0	0	1	1
oh	Ochric	1984		0	1	0	1	1
ohh	Hyperochric	1984		0	1	0	0	0
oi	Orthomineralic	1984		0	0	0	1	1
ok	Orthoskeletic	1984		0	0	0	1	1
ol	Oligoeutric	1984		0	0	0	1	1
om	Ombric	1984		0	1	1	1	1
or	Orthic	1984		0	1	0	0	0
os	Ortsteinic	1984		0	0	1	1	1
ot	Organotransportic	1984		0	0	0	1	1
oy	Oxygleyic	1984		0	0	0	1	1
p	Petric in CL and GY, Plinthic in all other RSGs; Pelocrustic in WRB 2022	1984		1	0	0	0	1
pa	Plaggic	1984		0	1	1	1	1
pb	Panpaic	1984		0	0	0	0	1
pc	Petrocalcic	1984		0	1	1	1	1
pd	Petroduric	1984		0	1	1	1	1
pe	Pellic	1984		0	1	1	1	1
pf	Profondic (WRB 1998, 2006, 2007) /// Plinthofractic (WRB 2014, 2015)	1984		0	1	1	1	0
pg	Petrogypsic	1984		0	1	1	1	1
ph	Pachic	1984		0	1	1	1	1

PH	Phaeozemic	1984		0	0	1	0	0
pi	Placic	1984		0	1	1	1	1
pk	Pretic	1984		0	0	0	1	1
pl	Plinthic	1984		0	1	1	1	1
PL	Planosolic	1984		0	0	1	0	0
plh	Hyperplinthic	1984		0	1	0	0	0
plo	Orthiplinthic	1984		0	1	0	0	0
plp	Epiplinthic	1984		0	1	0	0	0
plr	Paraplinthic	1984		0	1	0	0	0
pn	Planic (WRB 1998) /// Profondic (WRB 2014, 2015, 2022)	1984		0	1	0	1	1
po	Posic	1984		0	1	1	1	1
pp	Petroplinthic	1984		0	1	1	1	1
pq	Pelocrustic	1984		0	0	0	0	1
pr	Protic	1984		0	1	1	1	1
ps	Petrosalic	1984		0	1	1	1	1
pt	Petric	1984		0	1	1	1	1
PT	Plinthosolic	1984		0	0	1	0	0
ptn	Endopetric	1984		0	1	0	0	0
ptp	Epipetric	1984		0	1	0	0	0
pu	Puffic	1984		0	0	1	1	1
px	Pisoplinthic	1984		0	0	1	1	1
py	Petrogleyic (WRB 2006/07, 14/15) Pyric (WRB 2022)	1984		0	0	1	1	1
PZ	Podzolic	1984		0	0	1	0	0
q	Lithic	1984		1	0	0	0	0
qa	Protoandic	1984		0	0	0	1	1
qc	Protocalcic	1984		0	0	0	1	1
qd	Protoaridic	1984		0	0	0	1	0
qf	Prototephric	1984		0	0	0	1	1
qg	Protoargic	1984		0	0	0	1	1
qk	Protokalaic	1984		0	0	0	0	1
qp	Protospodic	1984		0	0	0	1	1
qq	Protogypsic	1984		0	0	0	0	1
qs	Protosodic	1984		0	0	0	1	1
qt	Prototechnic	1984		0	0	0	1	1
qv	Protovertic	1984		0	0	0	1	1
qw	Protostagnic	1984		0	0	0	1	1
qy	Protogleyic	1984		0	0	0	0	1
qz	Protosalic	1984		0	0	0	1	1
r	Rhodic	1984		1	0	0	0	0
ra	Reductaquic	1984		0	0	1	1	1
rb	Relictiturbic	1984		0	0	0	1	1
rc	Relocatic	1984		0	0	0	1	1
rd	Reductic	1984		0	1	1	1	1
rg	Regic	1984		0	1	1	0	0
RG	Regosolic	1984		0	0	1	0	0
rh	Rheic	1984		0	1	1	1	1
rk	Rockic	1984		0	0	0	1	1
rl	Relictigleyic	1984		0	0	0	1	1
ro	Rhodic	1984		0	1	1	1	1

rp	Ruptic (WRB 1998, 2006, 2007) /// Raptic (WRB 2014, 2015)	1984		0	1	1	1	1
rs	Rustic	1984		0	1	1	1	1
rt	Retic	1984		0	0	0	1	1
ru	Rubic	1984		0	1	1	1	1
rw	Relictistagnic	1984		0	0	0	1	1
rx	Radiotoxic	1984		0	0	0	1	
ry	Reductigleyic	1984		0	0	0	1	1
rz	Rendzic	1984		0	1	1	1	1
s	Salic in FL, Terric in HS	1984		1	0	0	0	0
sa	Sapric	1984		0	1	1	1	1
sb	Sombric	1984		0	0	0	1	1
sc	Solodic	1984		0	0	1	0	0
SC	Solonchakic	1984		0	0	1	0	0
sd	Spodic	1984		0	1	1	1	1
se	Sideralic	1984		0	0	0	1	1
sf	Sulfidic	1984		0	0	0	1	1
sh	Saprolithic	1984		0	0	0	0	1
si	Silic (WRB 1998) /// Someric (WRB 2014, 2015, 2022)	1984		0	1	0	1	1
sj	Siltinovic	1984		0	0	0	1	1
sk	Skeletic	1984		0	1	1	1	1
skn	Endoskeletic	1984		0	1	0	0	0
skp	Episkeletic	1984		0	1	0	0	0
sl	Siltic	1984		0	1	1	1	1
sm	Sombric (WRB 2006, 2007) /// Somerimollic (WRB 2014, 2015, 2022)	1984		0	0	1	1	1
sn	Silandic	1984		0	0	1	1	1
SN	Solonetzic	1984		0	0	1	0	0
so	Sodic	1984		0	1	1	1	1
son	Endosodic	1984		0	1	0	0	0
sow	Hyposodic	1984		0	1	0	0	0
sp	Spolic	1984		0	1	1	1	1
sq	Subaquic	1984		0	0	1	1	1
sr	Somerirendzic	1984		0	0	0	1	1
st	Stagnic	1984		0	1	1	1	1
ST	Stagnosolic	1984		0	0	1	0	0
stn	Endostagnic	1984		0	1	0	0	0
su	Sulphatic	1984		0	1	1	1	1
sv	Solimovic	1984		0	0	0	0	1
sw	Someriumbric	1984		0	0	0	1	1
sz	Salic	1984		0	1	1	1	1
szh	Hypersalic	1984		0	1	0	0	0
szn	Endosalic	1984		0	1	0	0	0
szp	Episalic	1984		0	1	0	0	0
szw	Hyposalic	1984		0	1	0	0	0
t	Thionic	1984		1	0	0	0	0
ta	Totilamellic	1984		0	0	0	1	1
tc	Tonguichernic	1984		0	0	0	1	1

TC	Technosolic	1984		0	0	1	0	0
td	Tidalic	1984		0	0	1	1	1
te	Technic	1984		0	0	1	1	1
tf	Tephric	1984		0	1	1	1	1
th	Thyric	1984		0	0	0	0	1
ti	Thionic	1984		0	1	1	1	1
tio	Orthithionic	1984		0	1	0	0	0
tit	Protothionic	1984		0	1	0	0	0
tk	Technoskeletic	1984		0	0	0	1	0
tl	Technoleptic	1984		0	0	0	1	0
tm	Tonguimollic	1984		0	0	0	1	1
tn	Transportic	1984		0	0	1	1	1
to	Tonguic	1984		0	0	0	1	1
tp	Thixotropic	1984		0	0	1	1	1
tr	Terric	1984		0	1	1	1	1
ts	Tsitelic	1984		0	0	0	0	1
tt	Technolithic Technotephric (WRB 2022)	1984		0	0	0	1	1
tu	Turbic	1984		0	1	1	1	1
tw	Tonguiumbric	1984		0	0	0	1	1
tx	Toxic	1984		0	1	1	1	1
ty	Takyric	1984		0	1	1	1	1
u	Urbic in AT, Umbric in AN, FL, GL, LP, PL, RG and Humic in AC, AL, CM, FR, NT, PT	1984		1	0	0	0	0
ub	Urbic	1984		0	1	1	1	1
ug	Umbriglossic	1984		0	0	1	0	0
um	Umbric	1984		0	1	1	1	1
UM	Umbrisolic	1984		0	0	1	0	0
uq	Uterquic	1984		0	0	0	1	1
v	Vertic	1984		1	0	0	0	0
vi	Vitric	1984		0	1	1	1	1
vm	Vermic	1984		0	1	1	1	1
vo	Voronic	1984		0	0	1	0	0
vr	Vertic	1984		0	1	1	1	1
VR	Vertisolic	1984		0	0	1	0	0
vt	Vetic	1984		0	1	1	1	0
w	Glossic	1984		1	0	0	0	0
wa	Wapnic			0	0	0	0	1
wc	Hypocalcic	1984		0	0	1	1	0
wg	Hypogypsic	1984		0	0	1	1	0
wi	Hypothionic	1984		0	0	0	1	1
wl	Hypoluvic	1984		0	0	1	0	0
wn	Hyposodic	1984		0	0	1	0	0
ws	Hyposalic (WRB 2006, 2007) /// Hyposulfidic (WRB 2014, 2015, 2022)	1984		0	0	1	1	1
x	Xanthic in FR, Chromic in all other RSGs	1984		1	0	0	0	0
xa	Xanthic	1984		0	1	1	1	1

y	Gypsic	1984		1	0	0	0	0
ye	Yermic	1984		0	1	1	1	1
yes	Nudiyermic	1984		0	1	0	0	0
yx	Phytotoxic	1984		0	0	0	1	0
z	Vitric	1984		1	0	0	0	0
zx	Zootoxic	1984		0	0	0	1	0

CODE	DESCRIPTION	FROM_ YEAR	TO_ YEAR	WRB_ 1998	WRB_ 06/07	WRB_ 14/15	WRB_ 2022
a	Ano-	1984		0	0	1	1
b	Thapto-	1984		1	1	1	1
c	Cumuli-	1984		1	1	0	0
d	Bathi- (1998) or Bathy- (WRB 06/07, 14/15, 22)	1984		1	1	1	1
e	Panto-	1984		0	0	1	1
h	Hyper-	1984		1	1	0	0
k	Kato-	1984		0	0	1	1
m	Amphi-	1984		0	0	1	1
n	Endo-	1984		1	1	1	1
o	Ortho-	1984		0	1	0	0
p	Epi-	1984		0	1	1	1
r	Para-	1984		1	1	0	0
s	Supra-	1984		0	0	1	1
t	Proto-	1984		1	1	0	0
w	Hypo-	1984		1	1	0	0

4.3 Classification full name

The full WRB classification name includes the RSG and all principal and supplementary qualifiers with their specifiers if relevant e.g. *Albic Endostagnic Luvisol (Cutanic, Differentic)*.The rules for naming the soil should be followed as outlined in the used WRB edition.

4.4 Diagnostics

Data fields in the PRF form: diagnostic_1 till 10

The WRB classification system builds on a number of diagnostics, which can be properties, materials or horizons. The list of possible diagnostics is provided in the online documentation. For definitions, consult the relevant edition of WRB.

CODE	DESCRIPTION	FROM_ YEAR	TO_ YEAR	TYPE	FAO 1988	WRB 1998	WRB 06/07	WRB 14/15	WRB 2022
hab	Albic horizon	1984		horizon			1	0	1
ham	Anthric horizon	1984		horizon			1		
haq	Anthraquic horizon	1984		horizon			1	1	1
hcc	Calcic horizon	1984		horizon			1	1	1
hch	Chernic horizon	1984		horizon			1	1	1
hcm	Cambic horizon	1984		horizon			1	1	1
hco	Cohesic horizon	1984		horizon			0	0	1
hcy	Cryic horizon	1984		horizon			1	1	1
hdu	Duric horizon	1984		horizon			1	1	1

hfg	Fragic horizon	1984		horizon			1	1	1
hfl	Ferralic horizon	1984		horizon			1	1	1
hfo	Folic horizon	1984		horizon			1	1	1
hfr	Ferric horizon	1984		horizon			1	1	1
hfu	Fulvic horizon	1984		horizon			1	1	0
hgy	Gypsic horizon	1984		horizon			1	1	1
hhg	Hydragric horizon	1984		horizon			1	1	1
hhi	Histic horizon	1984		horizon			1	1	1
hht	Hortic horizon	1984		horizon			1	1	1
hir	Irragric horizon	1984		horizon			1	1	1
hln	Limonic horizon	1984		horizon			0	0	1
hlv	Argic horizon	1984		horizon			1	1	1
hml	Melanic horizon	1984		horizon			1	1	0
hmo	Mollic horizon	1984		horizon			1	1	1
hna	Natric horizon	1984		horizon			1	1	1
hni	Nitic horizon	1984		horizon			1	1	1
hpb	Panpaic horizon	1984		horizon			0	0	1
hpa	Plaggic horizon	1984		horizon			1	1	1
hpc	Petrocalcic horizon	1984		horizon			1	1	1
hpd	Petroduric horizon	1984		horizon			1	1	1
hpg	Petrogypsic horizon	1984		horizon			1	1	1
hpk	Pretic horizon	1984		horizon			0	1	1
hpl	Plinthic horizon	1984		horizon			1	1	1
hpp	Petroplinthic horizon	1984		horizon			1	1	1
hpx	Pisoplinthic horizon	1984		horizon			1	1	1
hqv	Protovertic horizon	1984		horizon			0	1	1
hsd	Spodic horizon	1984		horizon			1	1	1
hsm	Sombric horizon	1984		horizon			1	1	1
hsz	Salic horizon	1984		horizon			1	1	1
hti	Thionic horizon	1984		horizon			1	1	1
htr	Terric horizon	1984		horizon			1	1	1
hty	Takyric horizon	1984		horizon			1	0	0
hts	Tsitelic horizon	1984		horizon			0	0	1
hum	Umbric horizon	1984		horizon			1	1	1
hvo	Voronic horizon	1984		horizon			1	0	0
hvr	Vertic horizon	1984		horizon			1	1	1
hye	Yermic horizon	1984		horizon			1	0	0
mab	Albic material	1984		material			0	1	0
may	Aeolic material	1984		material			0	0	1
mca	Calcaric material	1984		material			1	1	1
mcq	Claric material	1984		material			0	0	1
mco	Colluvic material	1984		material			1	1	0
mdo	Dolomitic material	1984		material			0	1	1
mek	Technic hard rock or material	1984		material			1	1	1
mfv	Fluvic material	1984		material			1	1	1
mgp	Gypsiric material	1984		material			1	1	1
som	Soil Organic material	1984		material			1	1	1
soc	Soil Organic Carbon	1984		material			0	1	1

mjs	Hypersulfidic material	1984		material			0	1	1
mlm	Limnic material	1984		material			1	1	1
mmn	Mineral material	1984		material			1	1	1
mmm	Mulmic material	1984		material			0	0	1
moc	Ornithogenic material	1984		material			1	1	1
mte	Artefacts	1984		material			1	1	1
mtf	Tephric material	1984		material			1	1	1
mti	Sulphidic material	1984		material			1	1	
mws	Hyposulfidic material	1984		material			0	1	1
msv	Solimovic material	1984		material			0	0	1
mot	Organotechnic material	1984		material			0	0	1
pab	Albeluvic tonguing or glossae	1984		property			1	1	1
pad	Aridic properties	1984		property			1	1	0
pak	Anthric properties	1984		property			0	1	1
pan	Andic properties	1984		property			1	1	1
pap	Abrupt textural change or difference	1984		property			1	1	1
pcc	Secondary carbonates or protocalcic properties	1984		property			1	1	1
pfl	Ferralic properties	1984		property			1	0	0
pgl	Gleyic colour pattern or Gleyic properties	1984		property			1	1	1
pgr	Geric properties	1984		property			1	1	0
ple	Continuous rock	1984		property			1	1	1
prd	Reducing conditions	1984		property			1	1	1
prp	Lithological or Lithic discontinuity	1984		property			1	1	1
pqq	Protogypsic properties	1984		property			0	0	1
prt	Retic properties	1984		property			0	1	1
pse	Sideralic properties	1984		property			0	1	1
pss	Shrink-swell cracks	1984		property			0	1	1
pst	Stagnic colour pattern or Stagnic properties	1984		property			1	1	1
pty	Takyric properties	1984		property			0	1	1
pvi	Vitric properties	1984		property			1	1	1
pvr	Vertic properties	1984		property			1	0	0
pye	Yermic properties	1984		property			0	1	1

4.5 Depth of diagnostics

Data fields in the PRF form: diagnostic_depth_1 till 10

The depth at which certain diagnostics have been identified, is key to the classification system. The PRF file foresees a numeric data field to report this depth. Note that the depth in cm from the upper limit of the mineral soil should be reported. These are positive number for the mineral soil and peat soils thicker than 40 cm. The numbers are negative for the forest floor layers. ***Herewith the ICP Forests Manual deviates from the rules on depth measurements of WRB. However, during the classification of the soil profile, the rules of WRB should be maintained for sake of harmonisation with the international classification system***. The PRF form allows to report up to 10 diagnostics.

4.6 WRB publication

Data fields in the PRF form: diagnostic_1 till 10 and diagnostic_depth_1 till 10

Throughout the existence of the ICP Forests programme, soil classification systems have evolved. For sake of harmonisation within the programme, it is essential that proper reference is made the applied WRB edition use for data reporting in the PRF and PFH file.

CODE	DESCRIPTION	FROM_ YEAR	TO_ YEAR
06ar	WRB 2006, Arabic version	1984	
06en	World Reference Base for Soil Resources, World Soil Resources Reports N° 103. FAO, Rome. - Final Version 2006	1984	
06es	WRB 2006, Spanish version	1984	
06pl	WRB 2006, Polish version	1984	
06ru	WRB 2006, Russian version	1984	
06sk	WRB 2006, Slovak version	1984	
06tr	WRB 2006, Update 2007, Turkish version	1984	
07en	World Reference Base for Soil Resources, World Soil Resources Reports N° 103. FAO, Rome - first update 2007	1984	
07ge	WRB German version 2007 provided by the Federal Institute for Geosciences and Natural Resources (BGR)	1984	
14en	WRB 2014, Version 2014	1984	
15en	WRB 2014, Update 2015	1984	
15es	WRB Spanish version 2014, update 2015	1984	
15fr	WRB French version 2014, update 2015	1984	
15ru	WRB Russian version 2014, update 2015	1984	
22en	WRB 2022,IUSS Working Group on WRB, 4th edition	2022	
98en	World Reference Base for Soil Resources, World Soil Resources Reports N° 84. FAO, Rome.	1984	
FAO88	Revised Legend of the FAO - UNESCO Soil Map of the World. World Soil Resources Reports N° 60. FAO, Rome.	1984	

4.7 Parent Material

Data fields in the PRF form: parent_material_1, parent_material_2

See coding list provided in the online documentation (second part of the table, European Soil Database, v2.0, 2004). In case the soil profile has been developed in two types of superimposed parent materials within the upper 2 m of the soil profile, two codes can be provided.

E.g. loamy loess deposits on riverine sands:
parent_material_1: 7110
parent_material_2: 5300

4.8 Highest and lowest level of the groundwater table

Data fields in the PRF form: ground_water_highest; ground_water_lowest

See coding list provided in the online documentation.

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR
1	Groundwater table between 0 - 50 cm	1984	
2	Groundwater table between 50 - 100 cm	1984	
3	Groundwater table between 100 - 150 cm	1984	
4	Groundwater table between 150 - 200 cm	1984	
5	Groundwater table below 200 cm	1984	
9	No groundwater table observed	1984	

4.9 Type of water table

Data fields in the PRF form: water_table

See coding list provided in the online documentation.

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR
1	Perched water table	1984	
2	Permanent water table	1984	
9	No water table observed	1984	

4.10 Water availability

Data fields in the PRF form: water

See coding list provided in the online documentation.

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR
1	Insufficient	1984	
2	Sufficient	1984	
3	Excessive	1984	
9	Unknown	1984	

4.11 Humus

Data fields in the PRF form: humus

For the humus forms, the Expert Panel on Soil and Soil Solution decided to follow the system of Zanella et al. (2018) which has been summarised in Zanella et al. (2022). See coding list and brief description provided in the table below and in the online documentation. For the coding of the horizons, see Chapter 5.3 of this Annex II. Important in the classification of humus forms is that the characteristics of the organo-mineral A horizon are taken into account.

CODE	DESCRIPTION	DESCRIPTION_full	FROM_YEAR	TO_YEAR
1	Mull	1. Absence of an OH horizon, and 2. In temperate climate: presence of a zoA horizon containing earthworms, or 3. In dry tropical, subtropical and Mediterranean climates: presence of large (> 1 mm) arthropod droppings, or/and 4. In non-tropical environments: pH(H_2O) of the A horizon ≥ 5	1984	
2	Moder	1.Presence of zoOH and zoOF horizons, and 2. Presence of biomicro (≤ 1 mm) aggregates in the A horizon (absence of other zoogenic aggregates), or 3. Presence of a nozA horizon , and 4. pH(H_2O) of the A horizon < 5; 5. presence of a gradual (> 5 mm) transition between OH and A horizons; 6. in general, on acid parent material	1984	
3	Mor	1. Presence of a nozOH or szoOH (no or rare droppings), or/and nozOF horizons, and 2. if an organo-mineral AE or a mineral E horizon is present, it is devoid of faunal droppings, and 3. In non-tropical environment: pH(H_2O) of A, or AE or E horizon < 4.5; 4. presence of a very sharp transition (< 3 mm) between organic and the organo-mineral layer; 5. in general, on acid parent material	1984	
4	Amphi (or Amphihumus)	1. Presence of zoOH and zoOF horizons, and 2. High amount of large (> 1 mm) aggregates in the zoA horizon, and 3. A horizon at least twice the thickness of OH; 4. in non-tropical environment: pH(H_2O) of the A horizon ≥ 5; 5. In general on basic parent material	2007	
10	Tangel	1. Presence of zoOH and zoOF horizons, and 2. Possible A horizon at the bottom of the profile at the bedrock contact, and 3. In non-tropical environment: pH(H_2O) of the A horizon ≥ 5; 4. OH horizon more than twice the thickness of A; 5. In general, on basic parent material		
5	Peat		1984	2006
5	Anmoor	Presence of a dominant AnA organo-mineral horizon 1. zoHS, lHS possible but never thicker than anA 2. Generally in wet base-rich environment (around springs, non-dynamic part of brook or river valley systems)	2007	
6	Histomull	Hz dominant with high faunal activity (anecic worms) Drained eutrophic peat soils with high content of clay (10-30%) or peat with thin subdominant clay cover. Mostly grasslands, sometimes drained Elder woods Ectoorganic layers are rare or extremely thin	2007	2018

6	Other		1984	2006
7	Histomoder	Hs dominant, faunal activity mainly springtails	2007	2018
7	Raw (Roh)		1984	2006
8	Histomor	No or nearly no faunal activity Fibric (Hf) - mesic (Hfs) - sapric forms (Hs)	2007	2018
9	Histoamphi	Aa or Aaz is dominant Presence of a Hz arthropod activity and a Aaz horizon	2007	2018
11	Saprimoor	1. presence of zoHS or lHS at the top of the profile; and 2. nozHS possible but thinner than zoHS; and 3. HF or HM never present within the control section; and 4. very active biodegradation of plant remains and their complete integration in an organo-mineral horizon. 5. Generally in moist, base-rich environment (drained brook valleys, fens, floodplains)	2019	
12	Amphimoor	1. zoHS horizon dominant in thickness and present with HF or HM or HF and HM; and 2. HF and HM thinner than zoHS within the control section (first 40 cm below the surface); and 3. active to very active biodegradation of organic matter and mixing with organo-mineral matter 4. Generally in moderately moist base-poor environment (brook valleys) or base-rich (half drained fens)	2019	
13	Mesimoor	1. HF possible but never dominant; and 2. HM or nozHS present and thicker than other horizons; and 3. organic matter degradation more active/efficient than in Fibrimoor 4. Generally in wet moderately base-poor environment (brook valleys) or base-enriched (drained base-poor fens or bogs)	2019	
14	Fibrimoor	1. Presence of a thick HF horizon; and 2. HM possible but never thicker than HF; and 3. Organic matter degradation is slow or inhibited. 4. Generally in wet very base-poor environment (brook valleys and bogs)	2019	
99	Unknown		1984	

4.12 Effective soil depth

Data fields in the PRF form: eff_soil_depth (cm) ***(M)***

The effective soil depth is the soil depth that the tree roots can explore, so from the top of the mineral soil to the continuous rock. Use “999” to report depths known to be deeper that 100 cm without knowing the eact depth.

4.13 Other Observations

Any additional information related to the soil profile.

5 Completing the soil profile horizon description form (PFH)

5.1 Terms and definitions

Organic material (OM) (IUSS Working Group WRB, 2022) (from Greek *organon*, tool) consists of a large amount of organic matter in the fine earth and/or contains many dead thin plant remnants. It may show different stages of decomposition though it should be decomposed to at least the extent that it is not loose and/or recognisable dead plant remains comprise ≤ 90% of the volume (related to the fine earth and all dead plant remains). So the fallen organic residues with > 90% recognisable dead plant tissues and still loose form the litter layer (= OL layer). Organic material accumulates under both wet and dry conditions. The mineral component of the fine earth has a limited influence on soil properties.

Diagnostic criteria. Organic soil material must have one of the two following:

(1) ≥ 20 % soil organic carbon (by mass) in the fine earth plus the dead plant remnants of any length and a diameter of ≤ 5 mm; ***and***

(2) One or more of the following:

a. Contains ≤ 90% (by volume, related to the fine earth plus all dead plant remnants) recognizable dead plant tissues ***or***

b. Is not loose, ***or***

c. Consists of dead plant material still connected to living plants.

Recognisable remains

Recognisable remains are organic materials like leaves, needles, roots, bark, twigs and wood, fragmented or not, whose original organs are recognizable by the naked eye or with a 5-10 X magnifying hand lens. Fresh litter generally consists for 100% of recognizable remains (Zanella et al. 2010).

Humic components

Humic components are small particles of organic remains and/or grains of organic or organo-mineral matter mostly comprised of animal droppings of different sizes. The original organs which compose the litter and generate the small particles (free or incorporated in animal faeces) are not recognizable by the naked eye or with a 5-10 X magnifying hand lens. Bound mineral particles can be visible within the mass.

Well decomposed organic substrate generally consists for 100% out of humic components. However, the generated humic component can also be in the A horizon and organic (OL, OF, OH) horizons. Thus, an A horizon made of anecic and endogeic earthworm faeces as well as a totally, finely decomposed and mostly organic OH horizon resulting from enchytreid and microarthropod activities, can both be composed for 100% of humic components, despite differences in the animals responsible for the structure of the horizons (Zanella et al. 2010).

Fibric component

Non-decomposed or very weakly decomposed hygrophilous plant remains like sphagnum species, sedges, rushes, reeds... Whole plants, parts of them and/or free plant organs (leaves, needles, twigs, wood, roots...) sometimes lying in more or less dark coloured layers.

Sapric component

Homogeneous dark organic and organo-mineral matter comprised of well decomposed plant remains partly mixed with mineral particles. Plant structures are not visible to the naked eye or with a 5-10 X magnifying hand lens. Animal droppings are possible in periodically drained horizons and can be abundant in drained peats.

Mineral components

Mineral components are mineral particles of different sizes, free or very weakly bound to humic components and visible by the naked eye or with a 5-10 X magnifying hand lens.

Zoogenic transformed material

Zoogenic transformed materials are recognizable remains and humic components processed by animals i.e. leaves, needles and other plant residues more or less degraded by soil animals, mixed with animal droppings. A fine, powdered and/or grained structure (less than 1 mm) is typical in a terminal stage of faunal attack in an organic horizon. At this last level of biotransformation, the substrate (OH horizon) is essentially comprised of organic animal droppings of varying size (droppings of epigeic earthworms, macro-arthropods such as millipedes, woodlice and insect larvae, micro-arthropods such as mites and springtails and enchytraeids dominate). Within the A horizon, animal activity leads to different types of A horizons, depending on the animals' ability to dig into the mineral soil and thoroughly mix organic and mineral matter.

Non zoogenic transformed material

Non zoogenic transformed materials are recognizable remains and humic component processed by fungi or other non-faunal processes (i.e. leaves, needles and other plant residues more or less fragmented and transformed into fibrous matter by fungi. Recognizable and recent animal droppings are absent or not detectable by the naked eye in the organic horizons; fungal hyphae can be recognized as white, brown or yellow strands permeating the substrate; traces of animal activity (old bite marks, mucus) may sometimes be detectable but are always marginal. In the last stage of biodegradation of an organic horizon, non zoogenic substance may essentially be composed of brown, dry plant residues more or less in powder form or tiny fragments (OF and OH horizons), or be massive like a dark wet plastic clay (OH or very organic A horizons).

By the naked eye or with a 5-10 X magnifying hand lens, each topsoil horizon appears to be composed of recognizable remains, humic and mineral components (fig. 1). At the soil surface, the animals or plant cover shed litter (remains) on and within the soil. Animal remains exist too, but they are quite negligible compared to plant remains and often overlooked by the neophyte. Litter is made up of recognizable residues and humic components (because of soil biological activity). In the other direction, the geological substrate "leaks" fragments of rock, which in the topsoil become mineral (free grains) and humic (grains incorporated in faeces) components. The mineral component can also be increased by surface erosion. The process perceived by the naked eye hides a more complex world of chemical-physical–biological processes. In unfavourable conditions for soil fauna the process is mainly dominated by fungi. Therefore, the new definitions of zoogenic and non zoogenic transformed material have been coined to distinguish zoogenic biological transformation from mycogenic transformation. The aim of a naked eye examination is to collect initial data and information for the purposes of a more detailed research on the same system. The vocabulary terms have been selected with regards to a dynamic interpretation of current knowledge on the topsoil.

5.2 Horizon number

Data field in PFH form: horizon (M, K)

After delineation of the horizon boundaries, each horizon is numbered: 1, 2, 3 etc. While the horizon symbols may change according to new information, the horizon number is not to be changed at any point of the further profile description and sampling. The numbering starts from the interface between air and soil no matter whether the surface horizon is an organic or a mineral horizon (see Figure 3). If at a later stage, a new horizon is discovered or an existing horizon is subdivided, a new number should be created. Avoid renumbering of the existing horizons to keep the link with the initial description in the field.

5.3 Soil horizon designations

Data field in PFH form: hor_master, hor_subordinate

5.3.1 The O horizon or layer

The O horizon or layer is dominated by dead organic material, consisting of fresh, partially or completely decomposed litter (such as leaves, needles, twigs, mosses, and lichens) and, under certain circumstances, materials such as mosses and lichens, that has accumulated on the surface; it may be on top of either mineral or organic soil. This organic material can mainly be transformed in animal faeces. It is not saturated with water for prolonged periods. The mineral fraction of such material is only a small part of the volume of the material and generally is much less than half of the mass.

An O layer may be at the surface of a mineral soil or at any depth beneath the surface if it is buried. However, a horizon formed by illuviation of organic material into mineral subsoil is not an O horizon (FAO, 2006).

A subdivision of the organic O-layers is made according to the following definitions (Zanella et al. 2018):

5.3.1.1 OL-horizon (from Organic and Litter)

This organic horizon is characterised by an accumulation of mainly leaves/needles, twigs and woody materials (including bark), fruits etc.

This sublayer is generally indicated as litter (Klinka et al., 1981, Green et al., 1993, Jabiol et al., 1995, Delecour, 1980). It must be recognized that, while the litter is essentially unaltered, it is in some stage of decomposition from the moment it hits the floor and therefore it should be considered as part of the humus layer.

There may be some fragmentation, but the plant species can still be identified. So most of the original biomass structures are easily discernible. Leaves and/or needles may be discoloured and slightly fragmented. The humic components amounts to less than 10 % by volume; recognisable remains 10% and more, up to 100% in non-decomposed litter.

OL types (prefixes: n, v)

- nOL: new litter (age < 1 year), neither fragmented nor transformed/discoloured leaves and/or needles;
- vOL: old litter (aged more than 3 months, vetustus, verändert, verbleicht, viellie), slightly altered, discoloured, bleached, softened up, glued, matted, skeletonized, sometimes only slightly fragmented leaves and/or needles.

Notes:

1. The passage from nOL to vOL can be very rapid (1 to 3 months) or very slow (more than a year) according to types of litter (plant species composition), climate, season and level of soil biological activity

2. The OL layer does not form part of the soil profile classified by WRB. This has consequence for the delineation of the 0 cm line. So for classifying the forest soil profile according to WRB, the 0 cm line is just below the OL layer, at the top of the OF layer. Though when sampling for monitoring purposes within the ICP Forests programme, the 0 cm line is set at the boundary between the forest floor and the mineral soil.

5.3.1.2 OF-horizon (fragmented and/or altered)

The OF-horizon is a zone immediately below the litter layer. This organic horizon is characterised by an accumulation of partly decomposed (i.e. fragmented, bleached, spotted) organic matter derived mainly from leaves/needles, twigs and woody materials. The material is sufficiently well preserved to permit identification as being of plant origin (no identification of plant species).The proportion of humic components is between 10 % and 70 % by volume. Depending on humus form, decomposition is mainly accomplished by soil fauna (zoOF) or cellulose-lignin decomposing fungi (nozOF). Slow decomposition is characterised by a partly decomposed matted layer, permeated by hyphae.

Note: this is the **fragmented layer** in non-saturated soils (Klinka et al., 1981, Green et al., 1993, Jabiol et al., 1995, Delecour, 1980)

OF types (prefixes: zo, noz)

zoOF = content in zoogenic transformed material > 10% of the volume of the horizon;

nozOF = content in non-zoogenic transformed material 90% or more of the volume of the horizon;

5.3.1.3 OH-horizon (humus, humification, implicit zoOH)

The OH-horizon is characterised by an accumulation of dark, well-decomposed, amorphous organic matter. It is partially coprogenic, whereas the F horizon has not yet passed through the bodies of soil fauna. The humified H horizon is often not recognized as such because it can have friable crumb structure and may contain considerable amounts of mineral materials. It is therefore often misinterpreted and designated as the Ah horizon of the mineral soil and not as part of the forest floor as such. To qualify as organic horizon, it should fulfil the FAO/WRB requirements, as described above. The original structures and materials are not discernible. Humic components amounts to more than 70 % by volume. The OH is either sharply delineated from the mineral soil where humification is dependent on fungal activity (mor) or partly incorporated into the mineral soil (moder).

Note: This horizon coincides with what is called the **humus layer** (Klinka et al., 1981, Green et al., 1993, Jabiol et al., 1995, Delecour, 1980).

OH type (prefixes: szo) = slightly zoogenic OH. OH is always zoogenic in origin (implicit zoOH). However, pedofauna may disappear by lack of fresh substrates to be eaten, most faunal activity then taking place in the overlying zoOF horizon. By observing carefully the OH horizon it is possible to see remains of past faunal activity in the form of droppings, corpses, bitten leaf fragments, etc. However, sometimes this abandoned horizon is invaded by fungal mycelia and lack traces of animal activity, while it still cannot be confused with nozOF in which recognizable remains (pieces of leaves or needle) always dominate over humic component (faecal organic matter). The ascension of water in seasonally waterlogged soils may also change the appearance of the OH horizon.

Concerning the organic layers, a distinction is made between the water saturated organic layers, designated as ‘H’, and the aerated organic materials indicated as ‘O’.

5.3.2 The H horizon or layer

The H horizon or layer is dominated by organic material, formed from accumulations of fresh or partially decomposed organic material at the soil surface (which may be under water). All H horizons are saturated with water for prolonged periods or were once saturated but are now drained. A H horizon may be on top of mineral soils or at any depth beneath the surface if it is buried (FAO, 2006).

Distinction of subhorizons in the organic H-layers (Zanella et al., 2018):

5.3.2.1 HF (from Histic and fibric) horizon

Histic organic horizon consisting almost entirely of almost unchanged plant remains. Fibric component ≥ 90%, sapric component < 10% of horizon volume. Content of rubbed fibres ≥ 40% of soil by dry weight (105 °C)[1]. Von Post scale of decomposition: 1 to 3 (4, 5 possible)[2].

Remarks: Plant remains from mosses like Sphagnum species, sedges, rushes and reeds are recognizable. Fibric horizons are quite common in bogs and oligotrophic parts of isolated fens. These horizons are mainly composed of remains of Sphagnum and Eriophorum species. In mesotrophic fens, the Hf-horizon is mainly composed of remains of sedges and rushes. Fibric horizons in eutrophic fens are less common because of the fast decomposition in those environments. A further differentiation could be made on the base of the origin of the plant material (oligotrophic mosses, mesotrophic sedges, mesotrophic sedges and reeds).This could be adapted to national, regional and local circumstances.

Note: this horizon coincides with what is classified as **fibric** (Klinka et al., 1981, Green et al., 1993) or **fibrist** (Delecour, 1980).

5.3.2.2 HM (from Histic and mesic)

Histic organic horizon consisting of half decomposed organic material not fitting the definition of fibric (HF) or sapric (HS). Fibric component 10% to 70%, sapric component 90% to 30% by volume. Content of rubbed fibres 10 to 40% of soil by dry weight (soil dried at 105 °C), Von Post scale of decomposition: 4 to 7 (8 possible)[3].

Note: This horizon coincides with what is classified as **mesic** (Klinka et al., 1981, Green et al., 1993) or **hemist** layer in saturated soils (Delecour, 1980).

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[1] The content (by mass) of the total organic fraction is generally more than 80%. When saturated, this fibric horizon can have a water content of far more than 850% of the oven-dry weight (Soil Taxonomy 1975).

[2] von Post scale: (1) Undecomposed; plant structure unaltered; yields only clear water coloured light yellow brown; (2) almost undecomposed; plant structure distinct; yields only clear water coloured light yellow brown; (3) very weakly decomposed; plant structure distinct; yields distinctly turbid brown water, no peat substance passes between the fingers, residue not mushy.

[3] von Post scale: (4) weakly decomposed; plant structure distinct; yields strongly turbid water, no peat substance escapes between the fingers, residue rather mushy; (5) Moderately decomposed; plant structure evident, but becoming indistinct; yields much turbid brown water, some peat escapes between the fingers, residue very mushy; (6) strongly decomposed; plant structure somewhat indistinct, but more evident in the squeezed residue than in the undisturbed peat; about one-third of the peat escapes between the fingers, residue strongly mushy; (7) Strongly decomposed; plant structure indistinct, but recognizable; about one-half of the peat escapes between the fingers.

5.3.2.3 HS (from Histic and sapric)

Histic organic horizon in advanced stage of decomposition. Sapric content ≥ 70% of the horizon volume; fibric component less than 30% (Figure 9). Content of rubbed fibres < 10% of soil by dry weight (soil dried at 105 °C). Von Post scale of decomposition: 8 to 10[4].
Remarks: Sapric horizons of brook valley systems and around wells have mostly a higher mineral fraction than those in fens or bogs. Although at first sight quite similar, the horizons can differ in structure, pH, nutrient content and base saturation due to differences in water quality, vegetation and soil organisms.

Note: This horizon coincides with what is classified as **humic** (Klinka et al., 1981, Green et al., 1993) or **saprist** (Delecour, 1980).

There are three HS types (prefixes: zo, noz, l):

zoHS = Meso or macrostructured HS horizon with a high activity of soil animals, especially earthworms. The mineral fraction is less than 50% (Figure 10). Typically present in drained semiterrestrial humus forms (both naturally and artificially drained). Activity of earthworms is high. The mineral fraction (clay, loam and/or sand) is commonly high compared to that of fibric horizons;

nozHS = Massive HS horizon with low activity of soil animals. Common around bogs and rain fed ponds. Humification mainly results from the activity of microorganisms, which is typical of oligotrophic environments. Complexes of humic substances are acid and relatively poor in nutrients and bases and subject to eluviation when drained. The mineral fraction is variable;

lHS = HS horizon with a high percentage of mineral particles (clay, silt and sand). The mineral fraction is more than 50%. The mineral component may occur in the form of thin layers. The bioactivity is comparable to szoH.

5.3.3 The mineral soil layer and its master horizons and layers

5.3.3.1 The organo-mineral A horizon

A mineral horizon formed at the surface or below an O horizon, in which all or much of the original structure of the parent material has been obliterated and characterized by one or more of the following:

- An accumulation of humified organic matter intimately mixed with the mineral fraction and not displaying properties characteristic of E or B horizons (see below);
- Properties resulting from cultivation, pasturing, or similar kinds of disturbance;
- A morphology that is different from the underlying B or C horizon, resulting from processes related to its surface position.

If a surface horizon has properties of both A and E horizons but the dominant feature is an accumulation of humified organic matter, it is designated an A horizon.

Where the climate is warm and arid, the undisturbed surface horizon may be less dark than the underlying horizon and contains only small amounts of organic matter. It has a morphology

[4] von Post scale: (8) very strongly decomposed; plant structure very indistinct; about two-thirds of the peat escapes between the fingers, residue almost entirely resistant remnants such as root fibres and wood; (9) Almost completely decomposed; plant structure almost unrecognizable; nearly all the peat escapes between the fingers; (10) Completely decomposed; plant structure unrecognizable; all the peat escapes between the fingers.

distinct from the C layer, though the mineral fraction may be unaltered or only slightly altered by weathering; such a horizon is designated A because it is at the surface. Examples of surface horizons which may have a different structure or morphology due to surface processes are Vertisols, soils in pans or playas with little vegetation, and soils in deserts.

Recent alluvial, colluvial or aeolian deposits that retain fine stratification are not considered to be an A horizon unless cultivated.

The different diagnostic A horizons are identified in the field observing the soil mass by the naked eye or with 5-10X magnifying hand lens, assessing the structure (Soil Survey Manual (1993) and FAO Guidelines 2006) and consistence, and measuring the acidity (pHwater).

Zanella et al. (2018, 2022) distinguishes the following five diagnostic A horizons:

5.3.3.1.1 Zoogenic A horizons (zoA)

maA: biomacrostructured A horizon = Aneci-endovermic

General characteristic: mixed biogenic organo-mineral peds dominate

Diagnostic criteria:

To be identified as a biomacrostructured A horizon, a layer must have at least four of the following:

- structure grade, observable in place in undisturbed soil: never weak, never lack of structure;
- presence of peds, observable in place in undisturbed soil as well as in the palm of the hand after applying a weak-moderate pressure on a sample of soil: all sizes of peds are present, but the volume of peds larger than 4 mm is greater than the volume of all other peds or units of soil;
- structure (FAO and USDA) - grade: moderate or strong; size if granular shape: medium (2-5 mm) and/or coarser; size if subangular blocky shape: fine (5-10 mm) or fine (5-10 mm) and very fine (< 5 mm);
- living earthworms, or earthworm galleries and/or casts;
- earthworm galleries within underlying horizon;
- pH in water >5.

Origin:

Biological: the whole horizon is made of anecic and endogeic earthworm faeces (the limit of 4 mm is rarely reached by droppings of arthropods and epigeic earthworms); roots and fungal hyphae (visible or not) also play an important role in the formation and stability of aggregates. Living earthworms or their galleries and casts are always present within the horizon.

meA: biomesotructured A horizon = Endo-epivermic

General characteristic: composed of coloured organic (dark) or/and organo-mineral biogenic peds

Diagnostic criteria:

The biomesotructured A horizon has all the following properties:

- structure grade, observable in place in undisturbed soil: never weak, never lack of structure;
- presence of peds, observable in place in undisturbed soil as well as in the palm of the hand after applying weak pressure on a sample of soil: all sizes of peds are present, but the volume of the peds larger than 1 mm and smaller than 4 mm is greater than the volume of all the other peds or parts of soil;
- structure (FAO and USDA) - grade: moderate or strong (rarely weak); size if granular shape: fine (1-2 mm) and/or medium (2-5 mm); size if subangular blocky shape: very fine (<5 mm).
- living earthworms, arthropods or enchytraeids or their droppings.

Origin:

Biological: earthworms (mostly epigeic and small endogeic), enchytraeids and arthropods are responsible for the structure; roots and fungal hyphae are also involved. Anecic and large endogeic earthworm droppings, classified typically as biomacro peds, are generally larger than 4 mm.

NB.: Green et al. (1993) described a rhizomull characterized by an A horizon which could be a biomesostructured A horizon. In this case, the thick mat of fine roots of grasses plays a major role in determining the type of structure of the topsoil.

miA: biomicrostructured A horizon = Enchy-arthropodic

General characteristic: composed of fine mineral grains mixed with fine organic particles and dark-coloured biogenic peds (holorganic or hemiorganic)

Diagnostic criteria:

The biomicrostructured A horizon has at least five of the following properties:

- absence of peds > 4 mm; observable both in situ, in undisturbed soil, and in the palm of the hand after applying a slight pressure on a sample of soil: peds of varying size can be present, but the volume of peds smaller than 1 mm is greater than the volume of all other peds or parts of the soil; gently squeezing the soil, almost all large peds easily reduce into smaller units;
- structure (FAO and USDA) - grade: moderate, strong; shape: granular; size: very fine (< 1 mm);
- presence of (generally uncoated) mineral grains (mineral component > 10%);
- > 10% organic particles and dark-coloured biogenic peds (holorganic or hemiorganic = humic component)
- living arthropods, enchytraeids or their droppings;
- pH in water <5.

Origin:

Biological: the horizon has an important amount of faecal pellets, droppings of enchytraeids (potworms) (larval stages, insects, spiders, mites, springtails…), micro-arthropods and particles of organic matter (remains of decomposed litter). Hyphae and roots are also very common.

Field identification:

- Take a sample of A horizon rich organic soil material. If squeezed gently in the palm of the hand, the sample breaks up into units composed of organic and organo-mineral peds (single or bound droppings, droppings bound to mineral grains), organic particles and mineral grains. Observing the soil with a magnifying hand lens (5-10X) reveals a lot of complex (partially) organic peds. Their mean size is less than 1 mm but the structure of the soil is clearly expressed and never weak or absent. The appearance can be very similar to that of the OH horizon.

- Observed on sandy or loamy substrate (acid or non-calcareous). The large amount of quartz grains (> 50%) seems to prevent the formation of a larger size structure or a massive one.

5.3.3.1.2 Non-zoogenic A horizons (nozA)

- To the naked eye, or with the help of a hand lens, this horizon does not show relevant signs of animal activity (absence of burrows; droppings, mucus coatings, animal remains, etc. < 5% of soil volume). Zoological agents are not involved in soil aggregation. Fungus- and root-derived aggregates can be visible.

sgA: single grain A horizon

General characteristic: single grained structure, biological aggregation absent or involving less than 5% of the soil volume

Diagnostic criteria:

To be identified as a single grain A horizon, a layer must have at least four of the following:

- an unbound loose consistence (undisturbed soil mass);
- structure (FAO and USDA): single grain;
- presence of clean (= uncoated) mineral grains;
- <10% of fine organic particles and/or dark-coloured biogenic peds;
- pH in water < 5.

Origin: Mineral grains coated with organic matter indicate a process of podzolisation in places. Faecal pellets of micro-arthropods or enchytraeids are sometimes present but irrelevant (< 10%).

Field identification for structure and consistency:

In undisturbed soil - Structure: single grain. Sub-units of soil do not appear bound together or are weakly bound in a casual manner. Sometimes, in a relatively organic sample, very small peds (< 1 mm) are detectable in the mass (animal pellets), because of their dark colour and organic composition in a light mineral mass. At other times the horizon looks like a brownish-red coloured nearly uniform fluffy mass. In this case, it is very difficult to separate mineral from scarcely present organic components.

In a sample of soil in the palm of the hand - When squeezing gently with the fingers, the sample breaks up progressively into large then fine, artificial units. The fine units are mostly mineral, more or less coloured by organic matter in coatings. Animal pellets are absent or in traces (less than 10%). The sample could be wrongly classified as weak medium granular structured but grains, never zoogenic, break easily into micro units because they are very weakly attached together in variable manner and size (no apparent soil structure).

Horizon designation: Because of observable processes of eluviation or podzolisation, the horizon could be classified as EA (or E) or AB following its similarity to mineral horizons.

msA: massive A horizon

General characteristic: massive structure, biological aggregation absent or involving less than 5% of the soil volume

Diagnostic criteria:

To be identified as a massive A horizon, a layer must have at least three of the following:

- heterogeneous but one-piece matrix;
- structure (FAO and USDA): massive;
- presence of clean (= uncoated) mineral grains;
- pH in water < 5.

Origin: Presence of mineral grains coloured by organic matter in coatings. Cohesion forces among parts of soil seem equally distributed in the soil, as they depend mostly on physical or chemical conditions rather than biological aggregation (peds originated by animals < 5%). Past biological activity (incorporation of organic matter) could also be involved in the process of formation of the horizon, but traces of current biological activity are never visible. Pellets of microarthropods or enchytraeids are present (< 5% of the soil volume). A 5-10 X magnifying hand lens is necessary to detect the composition of the pellets or grains, the size of the most common biostructured units being less than 1 mm.

Field identification for structure and consistency:

In undisturbed soil - Structure: massive. The units of soil are bound together in a relatively compact manner. No planes or zones of weakness are detectable in the mass, which appears as a heterogeneous coloured layer of organo-mineral soil.

If the soil is dry, when applying a moderate to strong pressure with the fingers, the soil sample progressively breaks up into finer artificial units. These fine units have a varying composition: mineral, organo-mineral and organic. If the soil is moist, the shape of the sample can be modified as in a tender, plastic, non-elastic matter.

Horizon designation: Because of observable processes of eluviation or initial podzolisation, the horizon could be classified as AE (or EA), following its resemblance to a mineral E horizon.

5.3.3.1.3 The histic organo-mineral (anA, from A horizon and anmoor)

Histic organo-mineral horizon mostly formed by microorganisms (actinomycetes), dark coloured, with plastic and massive structure, both high and low base saturation is possible. Meso and microfauna may be abundant during aerated periods, but the typical structure of their droppings is rapidly destroyed by water immersion and permanence. Because of long periods of immersion, the oxidation of organic matter is slow, conferring it a dark colour due to partially oxidized organic matter in the soil.

5.3.3.2 E horizon

A mineral horizon in which the main feature is loss of silicate clay, iron, aluminium, or some combination of these, leaving a concentration of sand and silt particles, and in which all or much of the original structure of the parent material has been obliterated.

An E horizon is usually, but not necessarily, lighter in colour than an underlying B horizon. In some soils, the colour is that of the sand and silt particles but, in many soils, coatings of iron oxides or other compounds mask the colour of the primary particles. An E horizon is most commonly differentiated from an underlying B horizon in the same soil profile by colour of higher value or lower chroma, or both; by coarser texture; or by a combination of these properties. An E horizon is commonly near the surface, below an O or A horizon and above a B horizon, but the symbol E may be used without regard to position in the profile for any horizon that meets the requirements and that has resulted from soil processes.

5.3.3.3 B horizon

A horizon formed below an A, E, H or O horizon, and in which the dominant features are the obliteration of all or much of the original structure of the parent material, together with one or a combination of the following:

- Illuvial concentration of clay, iron, aluminium, humus, carbonates, gypsum, silica or some combination of these;
- Evidence of removal of carbonates;
- Residual concentration of iron and aluminium oxides;
- Coatings of humus and/or oxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying and underlying horizons;
- Alteration that forms silicate clay or liberates oxides or both, and that forms a granular, blocky, or prismatic structure if volume changes accompany changes in moisture content;
- Brittle consistence.

All kinds of B horizons are, or were originally, subsurface horizons. Included as B horizons are layers of illuvial concentration of carbonates, gypsum, or silica (these horizons may or may not be cemented) and brittle horizons that have other evidence of alteration, such as prismatic structure or illuvial accumulation of clay.

Examples of layers that are not B horizons are layers in which clay films either coat rock fragments or are on finely stratified unconsolidated sediments, whether the films were formed in place or by illuviation; layers into which carbonates have been illuviated but that are not contiguous with an overlying pedogenetic horizon; and layers with gley colours but no other pedogenetic changes.

5.3.3.4 C horizon

A horizon, excluding hard bedrock, that is little affected by pedogenetic processes (lacks properties of H, O, A, E, or B horizon). The material of C layers may be either like or unlike that from which the soil is presumed to have formed. A C layer may have been modified even if there is no evidence of pedogenesis. Plant roots can penetrate C layers, which provide an important growing medium.

Included as C layers are sediments, saprolite, and unlithified geological materials that, commonly, slake within 24 hours when air-dry chunks are placed in water and, when moist, can be dug with a spade. Some soils form in material that is already highly weathered; such material that does not meet the requirements of A, E or B horizons is designated C. Changes not considered pedogenetic are those not related to overlying horizons. Layers having accumulations of silica, carbonates, or gypsum, even if indurated, may be included in C layers, unless the layer is obviously affected by pedogenetic processes; then it is a B horizon.

5.3.3.5 R layer

Hard bedrock underlying the soil. Granite, basalt, quartzite and indurated limestone or sandstone are examples of bedrock that are designated R. Air-dry or drier bits of an R layer, when placed in water, will not slake within 24 hours and are resistant to pressure with the fingers. The R layer is sufficiently coherent when moist to make digging with a spade impractical, although it may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may be fissured, but few roots can penetrate. The cracks may be coated or filled with clay or other material.

5.3.3.6 I layer

Ice lenses and wedges that contain at least 75% ice (by volume) and that distinctly separate organic or mineral layers in the soil.

In areas affected by permafrost, ice bodies may form lenses of wedges that separate entire soil layers. Where such ice concentrations occur within the depth of soil description, they can be designated as I layer.

5.3.4 Transitional horizons

There are two kinds of transitional horizons: those with properties of two horizons superimposed and those with the two properties separate.

For horizons dominated by properties of one master horizon but having subordinate properties of another, two capital letter symbols are used, such as AB, EB, BE and BC. The master horizon symbol that is given first designates the dominant properties: an AB horizon, for example, has characteristics of both an overlying A horizon and an underlying B horizon, but is more like the A than like the B.

In some cases, a horizon can be designated as transitional even if one of the master horizons to which it is apparently transitional is not present. A BE horizon may be recognized in a truncated soil if its properties are similar to those of a BE horizon in a soil in which the overlying E horizon has not been removed. An AB or a BA horizon may be recognized where bedrock underlies the transitional horizon. A BC horizon may be recognized even if no underlying C horizon is present; it is transitional to assumed parent material. A CR horizon can be used for weathered bedrock which can be dug with a spade though roots cannot penetrate except along fracture planes.

Horizons or layers in which distinct parts have recognizable properties of two kinds of master horizons are indicated as above, but the two capital letters are separated by a stroke (/), as E/B, B/E, B/C or C/R. Commonly, most of the individual parts of one component are surrounded by the other material.

5.4 Suffices

Data field in the PFH form: hor_subordinate (M)

Designations of subordinate distinctions and features within the master horizons and layers are based on characteristics observable in the field. Lower case letters are used as suffixes to designate specific kinds of master horizons and layers, and other features. The list of symbols and terms is explained more in detail below.

Suffix	Description	Combination with
L	See 5.3.1.1	O
F	See 5.3.1.2.	O
H	See 5.3.1.3.	O
F	See 5.3.2.1.	H
M	See 5.3.2.2.	H
S	See 5.3.2.3.	H
@	Evidence of cryoturbation: Irregular or broken boundaries, sorted rock fragments (patterned ground), or organic matter in the lower boundary between the active layer and permafrost layer.	O, H, A, E, B, C
b	Buried horizon: Used in mineral soils to indicate identifiable buried horizons with characteristics that were formed before burial. Horizons may or may not have developed in the overlying materials which may be either like, or unlike, the assumed parent material of the buried soil. [b like buried].	O, H, A, E, B

Suffix	Description	Combination with
c	Concretions or nodules (only used if following another suffix (k, q, v, y) that indicates the accumulated substance) [c like concretion].	
d	Drained [**d** like drained]	H
e	Saprolite [e like saprolit**e**]	C
f	Permafrost [f like frost]. Frozen soil: Designates a horizon or layer that contains permanent ice or is perennially colder than 0°C. It is not used for seasonally frozen layers or for bedrock (R). Dry frozen soil layers may be labelled (f).	O, H, A, E, B, C
g	Stagnic conditions: Designates a horizon with a distinct pattern of mottling that reflects alternating conditions of oxidation and reduction of sesquioxides, caused by seasonal surface waterlogging. If aggregates are present, the interiors of the aggregates show oxidising colours and the surface parts reducing colours. Accumulation of **Fe and/or Mn oxides** (related to the fine earth plus accumulations of Fe and/or Mn oxides of any size and any cementation class) predominantly *inside soil aggregates*, if present, and loss of these oxides on aggregate surfaces (A, B, and C horizons), **or loss of Fe and/or Mn by lateral subsurface flow (pale colours in ≥ 50% of the exposed area; E horizons);** **transport in reduced form [g like stagnic].**	A, B, C E
h	[h like humus] Significant amount of organic matter: in A horizons at least partly modified in situ; in B horizons predominantly by illuviation; in C horizons forming part of the parent material	A, B, C
i	Slickensides: In mineral soils, denotes the occurrence of slickensides, i.e. oblique shear faces caused by the shrink-swell action of clay; wedge-shaped polished peds and seasonal surface cracks are commonly present. [i like sl**i**ckensides]	B
j	Accumulation of jarosite and/or schwertmannite (related to the fine earth plus accumulations of jarosite and/or schwertmannite of any size and any cementation class) [j like **j**arosite].	O, H, A, E, B, C
k	[k like German ***K**arbonat*]. Accumulation of secondary carbonates (related to the fine earth plus accumulations of secondary carbonates of any size and any cementation class), evident by one or both of the following: • visible even in moist state, • has a calcium carbonate equivalent of ≥ 5% higher (absolute, related to the fine earth plus accumulations of secondary carbonates of any size and any cementation class) than that of an underlying layer and no *lithic discontinuity* between the two layers.	O, H, A, E, B, C
l	Accumulation of Fe and/or Mn in reduced form by *upward-moving capillary water* with subsequent oxidation (related to the fine earth plus accumulations of Fe and/or Mn oxides of any size and any cementation class): accumulation predominantly at soil aggregate surfaces, if present, and reduction of these oxides inside the aggregates [**l** like capillary].	H, A, B, C
m	Pedogenetic cementation in ≥ 50% of the volume (related to the whole soil); cementation class: at least moderately cemented (only used if following another suffix (k, l, q, s, v, y, z) that indicates the cementing agent) [**m** like cemented].	
n	Exchangeable sodium percentage ≥ 6% [n like **n**atrium].	E, B, C

Suffix	Description	Combination with
o	Residual accumulation of large amounts of pedogenetic oxides in strongly weathered horizons [o like **o**xide].	B
p	Modification by cultivation (e.g. ploughing); mineral layers are designated A, even if they belonged to another layer before cultivation [p like plough].	H, O, A
q	Accumulation of pedogenetic silica: If silica cements the layer and cementation is continuous or nearly continuous, qm is used.	A, E, B, C
r	Strong reduction: [r like **r**eduction]	A, E, B, C
s	Accumulation of Fe oxides, Mn oxides and/or Al (related to the fine earth plus accumulations of Fe oxides, Mn oxides and/or Al of any size and any cementation class) *by vertical illuviation processes* from above [s like sesquioxide].	B, C
t	Accumulation of clay minerals by illuviation process [t like German ***T****on*, clay].	B, C
u	Urban and other man-made materials: Used to indicate the dominant presence of man-made materials. [u like urban]	H, O, A, E, B, C, R
v	Plinthite: Indicates the presence of iron-rich, humus-poor material that is firm or very firm when moist and that hardens irreversibly when exposed to the atmosphere. When hardened, it is no longer called plinthite but a hardpan, ironstone, a petroferric or a skeletic phase – in which case v is used in combination with m.	restriction, C
w	Development of colour or structure in B: Indicates development of colour or structure, or both, in B horizons lacking other diagnostic characteristics. It is not used to indicate a transitional horizon. [w like **w**eathered].	B
x	Fragic characteristics (soil aggregates with a rupture resistance of at least firm and a brittle manner of failure, not allowing roots to enter the aggregates) [the x refers to the impossibility to enter the aggregates].	E, B, C
y	Accumulation of secondary gypsum of any size and any cementation class. [y like g**y**psum or Spanish ***y****eso*].	A, E, B, C
z	Presence of readily soluble salts [z like Dutch **z**out].	H, O, A, E, B, C

In 2022, the IUSS Working Group on WRB (2022) adopted a set of 'new' suffices, making use of Greek letter symbols:

Symbol	Criteria	Combination with
@	Cryogenic alteration.	H, O, A, E, B, C
α	Presence of primary carbonates (in R layers related to the rock, in all other layers related to the fine earth) [α like carbonate].	H, A, E, B, C, R
β	Bulk density ≤ 0.9 kg dm-3 [β like bulk density].	B
γ	Containing ≥ 5% (by grain count) volcanic glasses in the fraction between > 0.02 and ≤ 2 mm [γ like glass].	H, O, A, E, B, C
δ	High bulk density (natural or anthropogenic - not due to cementation (symbol ..m), not in fragic horizons (symbol x), not in layers with retic properties (symbol Bt/E)), so that roots cannot enter, except along cracks [δ like dense].	A, E, B, C

λ	Deposited in a body of water (limnic) [λ like limnic].	H, A, C
ρ	Relict features (only used if following another suffix (g, k, l, p, r, @) that indicates the relict feature) [ρ like relict].	
σ	Permanent water saturation and no redoximorphic features [σ like saturation]	A, E, B, C
τ	Human-transported natural material (related to the whole soil) [τ like transported].	H, O, A, B, C
φ	Accumulation of Fe and/or Mn in reduced form by lateral subsurface flow with subsequent oxidation (related to the fine earth plus accumulations of Fe and/or Mn oxides of any size and any cementation class) [φ like flow].	A, B, C

Conventions for using letter suffixes

Many master horizons and layers that are symbolized by a single capital letter will have one or more lowercase letter suffixes. More than three suffixes is cumbersome. The following rules apply:

- Letter suffixes should immediately follow the capital letter;
- A B horizon that has significant accumulation of clay and also shows evidence of development of colour or structure, or both, is designated Bt (t has precedence over w, s and h);
- Suffixes are listed alphabetically.

5.5 Prefixes of the humus classification

To accommodate the humus classification system of Zanella et al. (2018, 2022), it is necessary to report in the PFH form one additional field referring to the prefixes used by Zanella et al. (2018, 2022):

Prefix (Zanella et al. 2022)	Prefix	See also Annex II	In combination with
n	‘n’ from ‘new’	5.3.1.1	OL
v	‘v’ from ‘vetustus, verändert, verbleicht or viellie’	5.3.1.2	OL
zo	‘zo’ from zoogenic;	5.3.1.2, 5.3.1.3, 5.3.2.3, 5.3.3.1	OF, OH, HS, A
noz	‘noz’ from non-zoogenic	5.3.1.2, 5.3.1.3, 5.3.2.3, 5.3.3.1	OF, OH, HS, A
szo	‘szo’ from slightly zoogenic	5.3.1.3	OH

l	'l' from limnic	5.3.2.3.	HS
ma	Biomacrostructured	5.3.3.1.1	A
me	Biomesostructured	5.3.3.1.1	A
mi	Biomicrostructured	5.3.3.1.1	A
sg	Structure = single grain	5.3.3.1.2.	A
ms	Structure = massive	5.3.3.1.2.	A
an	Histic organo-mineral horizon, mostly formed by microorganisms (actinomycetes),	5.3.3.1.3.	A

5.6 Vertical subdivisions

Data field in PFH form: hor_vertical (M)

A horizon or layer designated by a single combination of letter symbols can be subdivided using arabic numerals following the letters. Within a C, for example, successive layers could be C1, C2, C3, etc.; or if the lower part is strongly reduced and the upper part is not, the designations could be C1-C2-Cr1-Cr2 or C-Cr1-Cr2-R.

These conventions apply whatever the purpose of subdivision. A horizon identified by a single set of letter symbols may be subdivided on the basis of morphology, such as structure, colour, or texture. These subdivisions are numbered consecutively. The numbering restarts with 1 at whatever level in the profile. Thus Bt1-Bt2-Btk1-Btk2 is used, not Bt1-Bt2-Btk3-Btk4.

The numbering of vertical subdivisions within a horizon is not interrupted at a discontinuity (indicated by a numerical prefix) if the same letter combination is used in both materials: Bs1-Bs2-2Bs3-2Bs4 is used, not Bs1-Bs2-2Bs1-2Bs2. A and E horizons can be subdivided similarly, for example Ap1, A1, A2, Ap2, A3; and E1, E2, Eg1, Eg2.

5.7 Discontinuities

Data field in PFH form: hor_discontinuity (M)

In mineral soils, arabic numerals are used as prefixes to indicate discontinuities. Wherever needed, they are used preceding A, E, B, C and R. They are not used with I, although this symbol clearly indicate a discontinuity. These prefixes are distinct from arabic numerals used as suffixes to denote vertical subdivisions.

A discontinuity is a significant change in particle size distribution or mineralogy that indicates a difference in the material from which the horizons formed or a significant difference in age, or both -unless that difference in age is indicated by the suffix b. Symbols to identify discontinuities are used only when they will contribute substantially to the reader's understanding of relationships among horizons. The stratification common in soils formed in alluvium is not designated as discontinuities - unless particle size distribution differs markedly from layer to layer - even though genetic horizons have formed in the contrasting layers.

Where a soil has formed entirely in one kind of material, no prefix is used (the whole profile is material 1). Similarly, the uppermost material in a profile having two or more contrasting materials is understood to be material 1, but the number is omitted. Numbering starts with the second layer of contrasting material, which is designated 2. Underlying contrasting layers are numbered consecutively. Even though a layer below material 2 is similar to material 1, it is designated 3 in the sequence. The numbers indicate a change in the material, not the type of material. Where two or more consecutive horizons formed in one kind of material, the same prefix number applies to all of the horizon designations in that material, e.g. Ap-E-Bt1-2Bt2-2Bt3-2BC. The number suffixes designating subdivisions of the Bt horizon continue in consecutive order across the discontinuity.

If an R layer is below a soil that formed in residuum and the material of the R layer is judged to be like that from which the material of the soil weathered, the arabic number prefix is not used. If the R layer would not produce material like that in the solum, the number prefix is used, as in A-Bt-C-2R or A-Bt-2R. If part of the solum formed in residuum, R is given the appropriate prefix: Ap-Bt1-2Bt2-2Bt3-2C1-2C2-2R.

In organic soils, discontinuities between different kinds of layers are not identified. In most cases the differences are shown by the letter suffix designations, if the different layers are organic, or by the master symbol if the different layers are mineral.

5.8 Horizon depth, thickness and boundary

Data field in PFH form: hor_upper; hor_lower; hor_distinctness; hor_topography

5.8.1 Horizon depth

The depth of the upper and lower boundary of each horizon is measured and reported in centimetres <u>from the surface of the mineral soil</u>.

If the soil is covered by (an) organic layer(s), either:

(a) 10 cm or more thick from the soil surface to a lithic or paralithic contact, or
(b) 40 cm or more thick,

then the depth is measured from the surface of the organic cover. The depth requirements correspond to the limit for Histosols (organic soils).

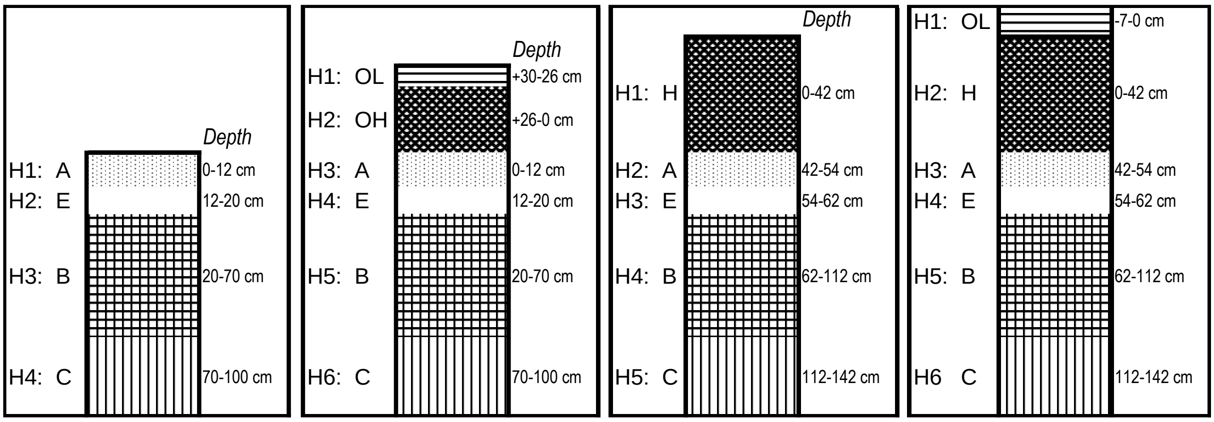

Figure Examples on how the horizon depth should be recorded in the field. These depths are important for the profile description and for the sampling.

- If the organic layer(s) is (are) too shallow to fulfil the above depth requirement(s), then its depth is recorded from the zero-point and upwards (see Figure 3), using negative depths.
- The depth is measured perpendicular to the slope.
- Most soil boundaries are zones of transition rather than sharp breaks. The distinctness together with the topography describe the transition between the different horizons and

substitute for the need to describe the depth ranges as for instance from 28 (25-31) cm to 45 (39-51) cm.

- Note that these rules deviate from the rules maintained in the classification of the soil profile according to WRB (2022). This means that for classification purposed only, the depths need to be recalculated to correctly follow the WRB classification key. Though it is not allowed to report these recalculated depths in the PFH form. In the PFH form, the above mentioned rules need to be followed.

5.8.2 Horizon boundary: distinctness and shape

For the horizon distinctness, this manual slightly deviates from IUSS Working Group on WRB (2022). As the ICP Forests programme combines the description of the forest floor (humus form) according to Zanella et al. (2018, 2022) and the description of the mineral soil or peat soils according to WRB (2022), there is a need to refine the horizon distinction classes.

CODE	DESCRIPTION	THICKNESS_OF_BOUNDARY_ZONE	FROM_YEAR	TO_YEAR
1	Extremely abrupt	0.3 - 1 cm	1984	2024
2	Very abrupt	1 - 2 cm	1984	
3	Abrupt	0 - 2 cm	1984	2024
4	Clear	2 - 5 cm	1984	
5	Gradual	5 - 15 cm	1984	
6	Diffuse	>15 cm	1984	
7	Very sharp	< 0.3	1984	
8	Sharp	0.3 – 0.5 cm	1984	
9	Sudden	0.5 – 1 cm	1984	

The horizon topography indicates the shape of the boundary. The characteristic refers to the layer’s lower boundary or, if the shape is ‘broken’, to the entire layer.

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR
1	Smooth - Nearly plane surface	1984	
2	Wavy - Pockets less deep than wide	1984	
3	Irregular - Pockets more deep than wide	1984	
4	Broken - Discontinuous	1984	
5	Complex	1984	2024

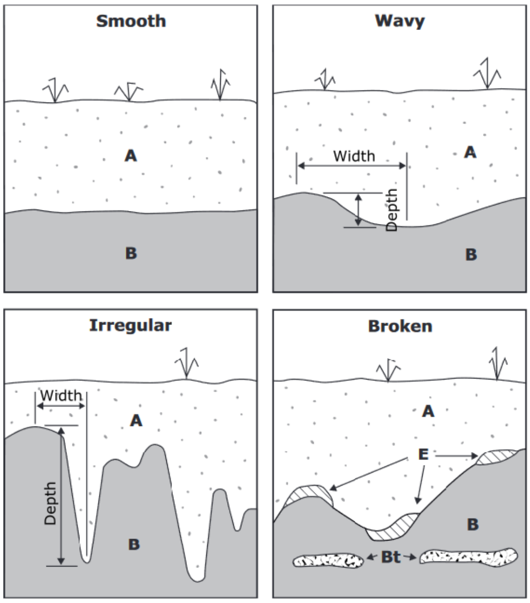

Figure: Shape of layer boundaries, modified from Schoeneberger et al. (2012) (IUSS Working Group on WRB, 2022)

5.9 Soil structure

Data field in the PFH form: structure (M)

Structure is the spatial arrangement of soil constituents and pores. If this is, at least partially, the result of soil-forming processes, it is called soil structure. Otherwise, it is rock structure. Structure refers to the fine earth. Structure is reported for mineral layers. Additionally, structure is reported for drained hydromorphic organic layers.

A **soil aggregate** is a discrete structural body that can be clearly distinguished from its surroundings and that results from soil-forming processes. If a force is applied to a specimen, and the specimen breaks along natural surfaces of weakness, it is composed of aggregates. If the specimen breaks exactly where force is applied, the structure is **massive** (coherent). If there is no coherence between the particles, the structure is of **single-grain** type. Human disturbance may create artificial structural elements, which are called **clods**.

Undisturbed aggregates or non-aggregated structure are called the first-level structure. Aggregates of the types subangular blocky, angular blocky, polyhedral, lenticular, platy, wedge-shaped, prismatic, and columnar may break into aggregates of a second-level structure and even further into aggregates of a third-level structure. The second-level and the third-level structure may be of the same type(s) as the first-level structure or of a different one. For the ICP Forests database, only the type of the first-level structure is mandatory to report. Figures (pg 184 – 186) in IUSS Working Group on WRB (2022) can help to identify the type of soil structure.

CODE	TYPE	DESCRIPTION	FROM_ YEAR	TO_ YEAR
1	Platy	Flat with vertical dimensions limited; generally oriented parallel to soil surface horizontally and, usually, overlapping with other structure types.	1984	
2	Prismatic	The dimensions are greater in the vertical than horizontal direction; vertical faces well defined, having flat or slightly rounded surfaces which are casts of the faces of the	1984	

		surrounding aggregates. Faces normally intersect at relatively sharp angles		
3	Columnar	Structures are prisms with rounded caps instead of flat surfaces.	1984	
4	Angular blocky	Blocks or polyhedrons, nearly equidimensional, having flat surfaces which are casts of the faces of the surrounding aggregates. In an angular blocky structure, the faces intersect at relatively sharp angles.	1984	
5	Subangular blocky	Same as 4 but with rounded faces.	1984	
6	Granular	Spheroids or polyhedrons, having curved or irregular surfaces which are not casts of the faces of surrounding aggregates. Units do not fit into each other	1984	
7	Cloddy (Crumbs, lumps and clods)	Granular-like pedality but with a very high inped porosity. Mainly created by artificial disturbance (e.g. tillage)	1984	
8	Massive	Material is a coherent mass (not necessarily cemented)	1984	
9	Single grain	Entirely non-coherent, e.g. loose sand	1984	
10	Wedge-shaped (e.g. slickensides)	Bounded by flat faces; interlocking wedges or lenses that terminate in pronounced angular vertices; ends of vertices may be missing; much accommodation to the faces of surrounding aggregates (typical for first-level or second-level structure in vertic horizons)	1984	
	Lenticular	Bounded by curved faces; overlapping, lens-shaped aggregates generally parallel to the soil surface that are thick at the centre and taper toward the edges; usually much accommodation to the faces of surrounding aggregates; formed by active or relict frost processes		
	Polyhedral	Bounded by relatively flat smooth, unequal faces; more than six faces; most vertices angular; usually much accommodation to the faces of surrounding aggregates; re-entrant angles between adjoining faces (typical for second-level structure in *nitic horizons*)		
	Flat-edged	Bounded by curved faces; lens-shaped aggregates that are thick at the centre and taper toward the edges; limited accommodation to the faces of surrounding aggregates (typical for second-level structure in nitic horizons)		
	Pseudosand/pseudosilt	Spheroidal units of sand and silt size, composed of kaolinite-oxide complexes; the complexes may be interconnected to each other; hand-texturing first yields the impression of a dominance of sand and silt and after prolonged squeezing proves the dominance of clay		
	Stratified	No structural units, rock structure, visible stratification from sedimentation		

5.10 Soil colour (moist and dry)

Moist colour is mandatory to be reported in PFH form, dry colour is optional

The colour of the **soil matrix** in each horizon should be recorded in moist and dry condition using the Munsell notation (e.g. Munsell Soil Colour Book, Pantone M50215 Floor Color Book, 2022). The colour notation is composed of hue, value and chroma. Hue is the dominant spectral colour (red, yellow, green, blue, violet), value is the lightness or darkness of colour ranging from 1 (dark) to 8 (light), and chroma is the purity or strength of colour ranging from 1 (pale) to 8 (bright). If there is no dominant colour, the horizon is described as mottled and two or more colours are given, making use of the observation field. In addition to the colour notations, the standard Munsell colour names should be recorded as well.

Examples:

- Greyish brown 10YR 5/2 (moist) and light brownish grey 10YR 6/2 (dry); where 10YR (yellowish red) is the hue, 5 (or 6) is the value and 2 the chroma.
- Dark greyish brown to greyish brown 2.5Y 4.5/2 (moist) and light brownish grey 2.5Y 6/2 (dry); Note that interpolation between colours is possible for hue, value and/or chroma
- Dark greenish grey 5GY 4/1 (moist) and greenish grey 10GY 5/1 (dry); where 5GY or 10GY (greenish yellow) is the hue, 4 (or 5) is the value and 1 is the chroma.

5.11 Soil texture

Data fields in PFH form: hor_texture_class (M), hor_clay (%), hor_sand (%), hor_sand (%)

The textural class can be estimated in the field by hand (finger test). For this, the soil sample must be moist (as close as possible but not exceeding the field capacity). Fragments >2 mm must be removed. See the flow chart in Chapter 8, Annex I Field Guide in IUSS Working Group WRB (2022). Please note that the flow chart only provides an estimation of the texture. Especially around the limits between the classes, the results might be not absolutely reliable. Beginners should ask experienced soil scientists for help. In addition the flow chart provides information on how to link the soil texture with the WRB qualifiers Clayic, Loamic, Siltic and Arenic.

Alternatively the soil texture is measured in the laboratory according to the Soil Analysis Method 3 (SA03): Determination of Particle Size Distribution, this Part X of the ICP Forests Manual, Annex I.

5.12 Coarse fragments

In PFH form: hor_coarse_vol and hor_coarse_weight (weight % in g/100g)

A coarse fragment is a mineral particle > 2 mm in its equivalent diameter. The subdivision of coarse fragments (0.6 to 60 cm) is according to their greatest dimension. Here we refer to natural coarse fragments. The abundance refers to the total percentage of the volume (related to the whole pedogenetic horizon) occupied by coarse fragments. Figures may help to estimate the volume (IUSS Working Group on WRB, 2022, pg 177).

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR
1	Very few (< 5% by volume)	1984	
2	Few (5 - 15% by volume)	1984	

3	Frequent or many (15 - 40% by volume)	1984	
4	Abundant (40 - 80% by volume)	1984	
5	Dominant or skeletal (> 80% by volume)	1984	
9	No stones or gravel	1984	

The PFH allow to report the code of the class of the estimated volume occupied by the coarse fragments and to report the percentage of coarse fragments, as a mass percentage (in g/100g). See Soil Analysis Method 5 (SA05): Determination of Coarse Fragments in Annex I of Manual Part X.

5.13 Horizon organic carbon

Determine and report the organic carbon content (g/kg) of the pedogenetic horizon using Soil Analysis Method 8 (SA08): Determination of Organic Carbon Content in Annex I of Manual Part X.

5.14 Horizon total nitrogen

Determine and report the total Nitrogen content (g/kg) of the pedogenetic horizon using Soil Analysis Method 9 (SA09): Determination of Total Nitrogen Content in Annex I of Manual Part X.

5.15 Horizon total $CaCO_3$

Determine and report the total carbonate content (g/kg) (if present) of the pedogenetic horizon using Soil Analysis Method 7 (SA07): Determination of Carbonate Content in Annex I of Manual Part X.

5.16 Horizon gypsum content

Determine and report the total gypsum content (g/kg) (if present) of the pedogenetic horizon. Gypsum is dissolved by shaking the sample with water. It is then selectively precipitated from the extract by adding acetone. This precipitate is re-dissolved in water and the Ca concentration is determined as a measure for gypsum. This method also extracts anhydrite.

5.17 pH of the horizon

Determine and report the Soil pH of the pedogenetic horizon using Soil Analysis Method 6 (SA06): Determination of Soil pH in Annex I of Manual Part X. Please specify in ‘other_observations’ if distilled water, KCl or CaCl2 was used.

5.18 Horizon electrical conductivity

Readily soluble salts are precipitated in dry soil and dissolved in moist soil. They are more soluble than gypsum. The presence of readily soluble salts is checked by measuring the electrical conductivity in the saturation extract (EC_{SE}). In the saturation extract, the soil is completely moist, but has no visible water surplus. This is not easy to achieve.
Alternatively, one can measure the electrical conductivity in an extract of 10 g soil with 25 ml aqua dest. ($EC_{2.5}$). Mix soil and water carefully, let it rest for at least 30 minutes and measure the electrical conductivity in the clear solution in dS m^{-1}. It must then be transformed into the

EC_{SE} according to the following equation: $EC_{SE} = 250 \times EC_{2.5} \times (WC_{SE})^{-1}$. For more information on how to estimate the WC_{SE}, consult IUSS Working Group on WRB (2022).

5.19 Horizon exchangeable base cations (Ca, Mg, K and Na) and cation exchange capacity

In WRB, the ammonium acetate pH7 method is used. See IUSS Working Group on WRB (2022).

5.20 Horizon porosity

Voids are related to the arrangement of the primary soil constituents and aggregates. They are the results of rooting, burrowing of animals and other soil forming processes such as cracking, translocation, leaching. The term void includes all air and water-filled spaces in the soil; the term pore is often used in a more restrictive way and does not include fissures or planes.

For many purposes, a qualitative description of porosity will suffice. For reference descriptions, voids are described in terms of type, size and abundance; continuity and orientation may also be recorded.

The porosity is an indication of the total volume of voids discernible with a x10 hand lens assessed by area and recorded as the percentage of the surface occupied by pores.

CODE	DESCRIPTION	FROM_YEAR	TO_YEAR
1	Very low (< 2 % by volume)	1984	
2	Low (2 - 5 % by volume)	1984	
3	Medium (5 - 15 % by volume)	1984	
4	High (15 - 40 % by volume)	1984	
5	Very high (> 40 % by volume)	1984	

5.21 Horizon measured or estimated bulk density

See Manual Part X, § 5.13. and Soil Analysis Method 4 (SA04) in Annex I.

5.22 Abundance of roots

Count the number of roots per dm^2 in each of the pedogenetic horizons, separately for the 4 diameter classes, and report the abundance classes using the codes ‘9, 1, 2, 3 or 4’.

CODE	DESCRIPTION	FROM_ YEAR	TO_ YEAR	VERY_FINE	FINE	MEDIUM	COARSE
1	Very few	1984		1 - 20	1 - 20	1 - 2	1 - 2
2	Few	1984		20 - 50	20 - 50	2 - 5	2 - 5
3	Common	1984		50 - 200	50 - 200	5 - 20	5 - 20
4	Many	1984		>200	>200	>20	>20
9	None	1984		0	0	0	0

5.23 Other observations

Use the 'other observations' field to report on the used laboratory analytical methods, reference to the estimation method for bulk density, etc.

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