Official Handbook
2nd National New Zealand Soil Judging Competition
25 -27th November 2021
Marlborough

Photo: Josh Nelson

Foreword

This manual is a revised and updated version of the handbook that was originally produced for the first Australasian Soil Judging Contest that was held in 2016 in Wanaka, New Zealand (Smith et al., 2016).
This adaptation is based on experience gained from Lincoln University's participation in previous soil judging competitions (Wanaka, New Zealand, 2016 – Toowoomba, Australia, 2017 – Canberra, Australia, 2018 – Adelaide, Australia, 2019 – Napier, New Zealand, 2019 – Golden Bay, New Zealand 2020, North Canterbury 2021). It is also tailored to the curriculum for "Soil Skills for Professionals" (SOSC901), designed to meet the skills required by scientists in the land-based sector in New Zealand.

The handbook is based on, and should be used in conjunction with, the New Zealand Soil Description Handbook (Milne et al, 1995) and the New Zealand Soil Classification (NZSC) scheme (Hewitt, 2010).

We acknowledge permission from Maanaki Whenua Landcare Research to use these resources.

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1. Site Characteristics

Refer to the chapter – Site Data in Milne et al. (1995) for full information on how to describe Site Characteristics.

For the competition the following site characteristics have to be determined:

- 1.1 Slope gradient
- 1.2 Geomorphic Position
  - 1.2.1 Landscape
  - 1.2.2 Landform
  - 1.2.3 Landform component or element
- 1.3 Parent Material
- 1.4 Erosion & Deposition
- 1.5 Vegetation Cover

1.1 Slope gradient

Slope stakes are placed to indicate the transect over which the slope gradient needs to be determined. The competitors are responsible for checking the heights of the stakes.

Use a clinometer to determine the **slope gradient** as a **percentage**.
Use Table 1 to convert the slope gradient (%) into a slope gradient class code and record this code on the scoresheet.

If a site falls on the boundary of two slope classes, mark the steeper class.

Table 1 Slope gradient class codes

CODE	DESCRIPTION	SLOPE GRADIENT (%)
01	Flat to level	**0-0.5**
02	Nearly level	**0.5-1.0**
03	Very gently sloping	**1.0-2.0**
04	Gently sloping	**2-5**
05	Sloping	**5-10**
06	Strongly sloping	**10-15**
07	Moderately steep	**15-30**
08	Steep	**30-60**
09	Very steep	**>60**

1.2 Geomorphic Position

1.2.1 Landscape

1.2.2 Landform

Landscape refers to the geomorphic location in the landscape. It can be determined from the surrounding landscape and the nature and/or origin of parent material.
Landform refers to the geological feature within the selected landscape.
E.g. A valley landform within a mountain country landscape

Determine the landscape and landform from the options in Table 2. Full descriptions can be found on pages 15 to 22 of Milne et al. (1995). Record the corresponding code to the scoresheet. (*Note: Not all codes are listed in this handbook, refer to Milne et al. for full lists).*

Slope stakes are placed to indicate the area over which site characteristic slope/terrain position needs to be determined.

Table 2 Landform and landscape codes

1.2.1 Code for landscape		1.2.2 Code for landform	
UP	Upland	**MT**	Mountain
MC	Mountain country	**HI**	Hill
HI	Hill country	**PT**	Plateau
HL	Hilly Land	**MR**	Moraine
LL	Low land	**VL**	Valley
PL	Plain	**DT**	Delta
		FP	Flood plain
		FB	Flood plain bench
		OP	Outwash plain
		SP	Sand Plain
		TR	Terrace
		FA	Fan
		DU	Dune
		BG	Bog
		SW	Swamp

1.2.3 Landform component and element

From Table 3 choose the landform component, and if applicable a landform element, that best describes the pit location. Full descriptions can be found on pages 15 to 22 of Milne et al. (1995). Record the corresponding class code, or codes, onto the scoresheet.
Figure 1 is there to help visualize some of the different options.

Table 3 Landform component codes (adapted from Milne et al., 1995)

CODE for LANDFORM COMPONENT		CODE for LANDFORM ELEMENT	
CR	Crest	**Landform elements for relatively flat areas**	
PT	Plateau	**MO**	Mound (higher part)
CL	Cliff	**IN**	Intermediate
SC	Scarp	**HO**	Hollow (“closed” lower part)
LO	Lobe	**CN**	Channel (“open” lower part)
GO	Gorge	**Landform elements for hilly/mountainous areas**	
VL	Valley	**SU**	Summit
FA	Fan	**FL**	Flank
GU	Gully	**US**	Upper slope
		MS	Mid slope
		FS	Foot slope
		TO	Toe

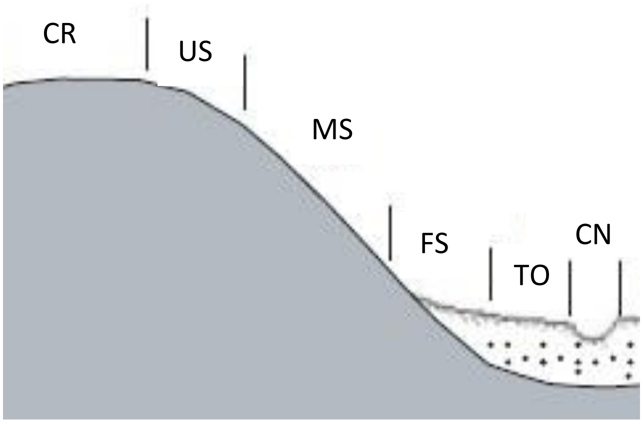


Figure 1 Slope positions (adapted from Schoeneberger et al., 2012)

1.3 Parent Material (Mode of origin and emplacement)

Using Table 4 record the applicable parent material **and** its mode of emplacement. **Either one or two codes may be used**, e.g., The parent may be sedimentary (SD) in origin but emplaced via Aeolian processes (AO) or it may be igneous (IG) and weathered in situ.

Table 4 Types of parent materials & modes of emplacements (Milne et al., 1995)

CODE	TYPE	DESCRIPTION
AO	Aeolian	Wind deposited sediments - Applicable for many rock types e.g. loess, sand & volcanic tuffs
BG	Biogenic	Organic rock produced by the remnants of living organisms both plant or animal e.g. limestone, peat.
CL	Colluvium	Unconsolidated, unsorted sediments detached from the hillslopes and deposited at a footslope by gravity and water.
FL	Fluvial	Material deposited by or related to water movement of rivers and streams.
GL	Glacial	Material or features relating to glacial activity. Also includes glacial lakes.
IG	Igneous	Rock or material solidified from molten or semi-molten material. Also includes any rocks affected by the formation of the above rocks (e.g. contact metamorphism)
LC	Lacustrine	Clastic sediments and chemical precipitates deposited in lakes.
LH	Laharic	Material produced by a lahar.
MR	Marine	Rock or material pertaining to, produced by, or formed in the sea or estuaries. Can be identified by presence of marine microfossils.
MM	Metamorphic	Rock or material pertaining to processes of metamorphism. *[Metamorphism: rocks altered from their original condition by combinations of heat and/or pressure, causing a change in physical and chemical condition of the rock].* *For the purpose of this competition greywacke sandstone will be counted as a sedimentary rock.*
OR	Organic Material	Any organic material (non-mineral) that doesn't fit into the biogenic or marine categories. Pertains to organic soils that have no mineral rocks in the profile.
SP	Saprolitic	Pertaining to saprolite *[Saprolite: A soft clay enriched material formed in place by weathering of rocks]*
SD	Sedimentary	Rock or material pertaining to or containing sediment(s) that has been cemented or compacted to some degree at some point in it's history.

1.4 Erosion/Deposition

Determine whether the site is erosional or depositional in nature and only fill out the applicable category on the score sheet. Record **X** in any non-applicable boxes to indicate you have determined that it is non-applicable.

An off-limit area will be marked at each soil pit for evaluating erosion. This area is marked at EACH pit. It is up to the competitors to determine whether erosion is applicable or not. Some locations may have more than one erosional and/or depositional processes occurring, if this is the case then **only the dominant erosional/depositional process is recorded**.

Table 5 Classification of category of erosion & deposition (Milne et al., 1995)

CODE	NAME	DESCRIPTION
CH	Channel	Erosion and/or deposition by water flowing in stream and river channels, including stream bank erosion, and associated deposition.
CR	Creep	The slow, gradual, more or less continuous, non-reversible deformation sustained by soil and rock material under gravitational stresses.
FA	Fall	A very rapid downward movement of a mass of rock or earth that travels mostly through the air by free fall, leaping, bounding or rolling. E.g. Rock fall, debris fall.
GU	Gully	Erosion creating gullies (Steep erosion channel between 0.5-10m deep), usually formed by water action.
RI	Rill	Erosion creating rill's (Steep erosion channel less than 0.5m deep), usually formed by water action.
RS	Rotational slip & slump	A slip or slump in which shearing takes place on a well-defined, curved shear surface, concave upwards in cross-section, producing backwards rotation in the displaced mass.
SC	Scree	Erosion which leads to production and deposition of scree downslope from the eroded area. (Scree; loose broken rock fragments, created from erosion on steep landforms).
SH	Sheet	Erosion in which thin layers of surface material are gradually removed more or less evenly from an extensive area of sloping land.
TS	Translational slide	Downslope displacement of soil-rock material on a surface which is roughly parallel to the general ground surface. Includes landslide like events including debris slide, mud flows, liquefaction slides, loess flow etc.
TN	Tunnel (piping)	Erosion by percolating water in a layer of subsoil resulting in caving and the formation of belowground tunnels or pipes.
WI	Wind	Detachment, transport, and deposition of loose material by wind action.

1.5 Vegetation Cover

Determine the dominant vegetation cover in the area surrounding or immediately adjacent to the pit using the classes in table 5. The dominant vegetation cover is determined by % cover of the landform. If two or more growth forms have similar cover %, then preference is given to the tallest class.
A full list of possible classes and descriptions can be found on pages 28 – 31 of Milne et al. (1995).

Table 6 Landform component codes (Milne et al., 1995)

Code for vegetation classes			
F	Forest	**GL/SE/RL**	Grass/Sedge/Rush-land
S	Scrub	**RD**	Reedland
T	Treeland	**CF**	Cushionfield
SL	Shrubland	**HF**	Herbfield
TF	Treefernland	**MF/LF**	Moss/Lichen-field
VL	Vineland	**R**	Rockland
TL	Tussockland	**BF/SF/GF/SD**	Boulder/Stone/Gravel/Sand-field
FL	Fernland	**Z/C/L/P**	Silt/Clay/Loam/Peat-field

2. Soil Description

Refer to the chapter – Soil Data in Milne et al. 1995 for full information on Soil Description.

For the competition the following soil data has to be determined:

- 2.1 Horizon designation
- 2.2 Lower boundary
- 2.3 Particle size
- 2.4 Structure and consistence
- 2.5 Matrix colour(s)
- 2.6 Redoximorphic features
- 2.7 Coatings
- 2.8 Roots

NOTES:

- A marker (nail) will be placed somewhere in the third horizon from the surface in the no-pick zone.
- At each pit there will be a sign to indicate how many horizons, and to what depth, the soil has to be described.
- The depth of the marker will also be noted on this sign.
- There is no minimum horizon depth, except for transitional horizons (eg AB or A/B). Boundaries between master horizons (eg A to B or B to C) will be described as transitional horizons when their thickness is >8cm.

2.1 Horizon designations

For complete information on horizon notation see Appendix 11 in Milne et al. (1995).

For each horizon determine:

- **Master prefix – See page 11**
  If applicable, a numerical or letter master prefix should be used.
- **Master letter(s) – Options in Table 7**
  At least 1 Master letter; a combination of 2 Master letters can be used for transitional horizons.
- **Letter suffix(es) – Options in Table 8 and Table 9**
  For A, B and E horizons at least 1 letter suffix and a maximum of 2 letter suffixes needs to be given.
  For C and R horizons 0 or 1 letter suffix can be given, dependent on applicability.
- **Numeric suffix – See page 14**
  Numeric suffixes can be used for any horizon that requires numerical subdivision.

Master prefixes

Lithological discontinuities – numerical prefix first in notation.

- Where a soil has formed entirely in one kind of material, a prefix is omitted from the symbol; the whole profile is material 1.
- 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.

Buried horizons – lower case prefix
There is 1 **lower case prefix**, b, it is used to denote a buried genetic horizon. ie.

Buried horizons – numerical prefix after lower case prefix – before master horizon letter.
By definition, a buried horizon is ***not*** in the same deposit as overlying horizons. (However, some buried horizons can be formed in material that is lithologically similar to the overlying deposit)

- Buried Ah in ***similar*** material as overlying horizon bAh
- Buried Ah in ***dissimilar*** material as overlying horizon 2bAh

Note: the use of numbering in the following sequence of buried soils and lithological discontinuities:

bAh	Ah of the first buried soil, formed in lithology 1 1b Ah with the 1 omitted
bBw	Bw of the first buried soil, formed in lithology 1 1b Bw with the 1 omitted
…………………………..	1st lithological discontinuity
2b 2Ah	Ah of the second buried soil, formed in lithology 2 2 for having formed in lithology 2, b 2Ah as part of second buried soil
…………………………..	2nd lithological discontinuity
3b 2Bw	Bw of the second buried soil, formed in lithology 3 3 for having formed in lithology 3, b 2Bw as part of second buried soil
3b 2Cu	Cu of the second buried soil, formed in lithology 3 3 for having formed in lithology 3, b 2Cu as part of second buried soil
3b 3Ah	Ah of the third buried soil, formed in lithology similar to lithology 3 3 for having formed in lithology 3, b 3Ah as part of third buried soil

Table Table 6 Master letter horizon designations options

MASTER HORIZONS	
O	Organic material, accumulated under wet conditions.
A	Mineral horizon formed at the soil surface characterised by incorporation of humified organic matter.
E	Horizon below the O, or A horizon that has lost clay, iron or aluminum (eluviated) leaving it relatively pale.
B	Mineral horizon that has been altered by formation of soil structure, brighter colours (than horizon above and below), or by enrichment in mineral or organic material.
C	Underlying unconsolidated material, usually showing some weathering, but minimal biological activity.
R	Underlying bedrock.
TRANSITIONAL MASTER HORIZONS*	
A/B	Zone of mixing between any two master horizons. (A and B are an example only)
BC	Transitional between any two master horizons. (B and C are an example only)

* ***Transitional Horizons** – There are two kinds of transitional horizons: those with properties of two horizons superimposed; and those with the two properties separate.*

- ***Separate**: Horizons 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 virgule (/), such as A/C, E/B, B/C and C/R. Commonly, most of the individual parts of one of the components are surrounded by the other.*
- ***Superimposed**: 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 kind of horizon whose properties dominate the transitional horizon.*

Table 7 Letter suffixes options

In A horizons the following letter suffixes are acceptable (choose 1)	
h	An A horizon in which there is no evident disturbance due to cultivation or pastoral land use.
p	An A horizon in which incorporation of organic matter has involved mixing due to cultivation or to increased biological activity associated with topdressing or manuring. It may contain material from pre-existing E, B or C horizons.
For B horizons the following letter suffixes are acceptable (at least 1, maximum of 2).	
fm	Sharply defined, cemented, pan-like B horizon usually less then 10 mm thick but the same designation is given to horizons up to 25 mm thick. It is black to reddish brown or dark red in colour, and a black upper part can often be distinguished from a reddish brown lower part. It lies roughly parallel to the soil surface but is commonly wavy or convolute. A Bfm horizon usually occurs as a single pan but in places it can be bifurcated. It forms a barrier to most roots and restricts water movement.
g	A strongly gleyed B horizon with more than 2% redox segregations and in which greyish colours, as specified below, occupy 50-85% of the matrix exposed in a cut face of the horizon or are dominant on ped faces.

Table 8 continues on the next page.

Table 8 continued.

h	Dark-coloured B horizon of podzolised soils enriched in organic matter, associated with aluminium, or iron and aluminium, as a result of illuviation.
k	To denote an accumulation of secondary carbonate.
o / o(f) / o(g) / og / or	A strongly weathered B horizon formed in mixed crystalline iron and aluminium oxides and kaolin minerals, with low activity clay properties. Refer to Table 9 for redox options.
r	Intensely gleyed B horizon with predominantly greyish colours and usually few redox segregations.
s / s(f) / s(g)	Ochreous B horizon of podzolised soils containing illuvial aluminium, iron, or both, that is closely associated, or complexed, with illuvial organic matter. The aluminium and iron is apparently mainly present as minerals with short-range-order (especially allophane and ferrihydrite), though some aluminium is often present as aluminium-humus. Refer to Table 9 for redox options.
t / t(f) / t(g) / tg / tr	B horizon containing translocated clay. It is required to have less than 2% redox segregations. Refer to Table 9 for redox options.
w / w(f) / w(g)	B horizon that shows evidence of alteration under well aerated conditions and does not qualify as Bh, Bs or Bt. Refer to Table 9 for redox options.
x / x(g) / xg	To denote a horizon with fragipan properties. Refer to Table 9 for redox options.
For C horizons the following letter suffixes are acceptable (at least 1, maximum of 2).	
g	A strongly gleyed C horizon with more than 2% redox segregations in which greyish colours as specified below occupy 50–85% of the matrix exposed in a cut face of the horizon.
r	Intensely gleyed C horizon with greyish colours with chromas of 2 or less occupying more than 85% of the matrix exposed in a cut face of the horizon.
x	To denote a horizon with fragipan properties.
For E horizons the following letter suffixes are acceptable (at least 1, maximum of 2).	
a	An E horizon in which weathered films on sand and silt particles are absent, very thin or discontinuous, so that the colour of the horizon is mainly determined by the colours of uncoated grains and redox segregations are absent. Not saturated with water and usually overlying Bh or Bs.
g	An E horizon with greyish colours and redox segregations with dominant moist chroma of 2 or less, or moist chroma of 3 with values of 6 or more, and with more than 2% redox segregations. Normally overlies Bg or Btg, but can overly Bfm or Bh.
r	An E horizon with dominantly grey colours attributable to reduction and removal of iron due to prolonged waterlogging. It has dominant moist chroma of 2 or less, and 0% or <2% redox segregations. Usually underlies an O horizon and overlies a Bg, Btg, Br, Bfm or Bh.
w / w(g)	An E horizon with dominantly brownish colour, it has a moist chroma of 4 or more but less than 6, and with less than 2% redox segregation (Ew, or enough segregations to qualify as Eg (Ew(g)).

Table 8 Suffixes used to express degrees of gleying in B horizons (adapted from Milne et al., 1995)

	% Redox Segregations*	% Low Chroma Colours* In matrix		On ped faces
Bw, Bt, Bs, Bo	<2	none		none
Bw(f), Bt(f), Bs(f), Bo(f)	≥2	none	and	none
Bw(g), Bt(g), Bs(g), Bo(g), Bx(g)	≥2	<50	/	<50
Bg, Btg, Bog, Bxg	≥2	50-85	or	>50
Br, Btr, Bor	Not diagnostic	>85		Not diagnostic

** Abundance charts can be found in Milne et al., 1995 – Appendix 2 and also in chapter 6 of this handbook.*

Vertical subdivision by figure suffixes

When a horizon (eg. Bt) needs to be subdivided, numerical suffixes follow at the end of the horizon noations.
The number will change if the suffix changes:

Bt1
Bt2
Btg1
Btg2

(not Bt1, Bt2, Btg3, Btg4)

The numbering of vertical subdivisions within a particular kind of horizon is not interrupted at a lithological discontinuity if the same letter combination is used in both materials:

Bw1
Bw2
………………………….. lithological discontinuity
2Bw3
2Bw4

2.2 Lower boundary

For complete information on horizon boundary descriptions see Milne et al. (1995) – pages 35 to 40.

Notes:

- The boundary distinctness of the deepest horizon will not be determined; leave these fields blank on the scoresheet.
- The last horizon boundary should be the specified judging depth. So, if the pit sign states “Describe 5 horizons to a depth of 140 cm.”, the fifth depth designation should be:
    - “140” if the specified depth is at a lithic or paralithic contact, or,
    - “140+” if the specified depths is not at a lithic or paralithic contact.

Depth to the lower boundary

For all but the last horizon, from the top of the mineral soil surface determine the depth in centimeters (to the nearest cm) to the lower boundary.

Depth measurements should be made between the tapes in the “no-pick” zone on the pit wall. Depth measurements will be considered correct within a range based on the distinctness and topography of the boundary.

Boundary distinctness

Determine the distinctness of the horizon boundaries according to Table 10 and Figure 2.

Record the corresponding codes to the scoresheet.

Table 9 Classification of horizon boundary distinctness (Milne et al., 1995).

DISTINCTNESS

Code	Class	cm
SH	Sharp	<0.5
AB	Abrupt	0.5-2
DS	Distinct	2-5
ID	Indistinct	5-10
DF	Diffuse	≥10

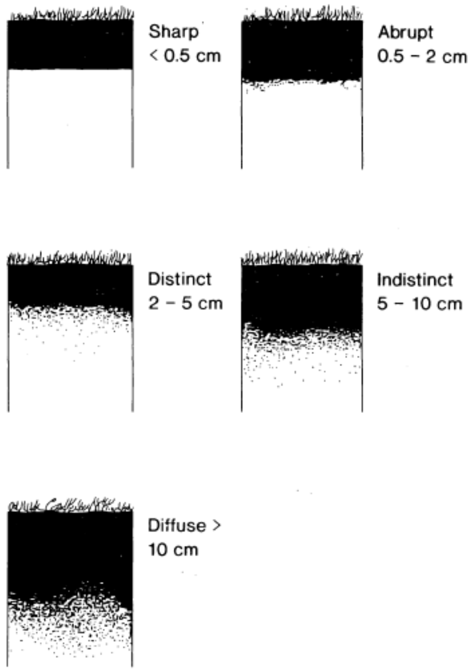
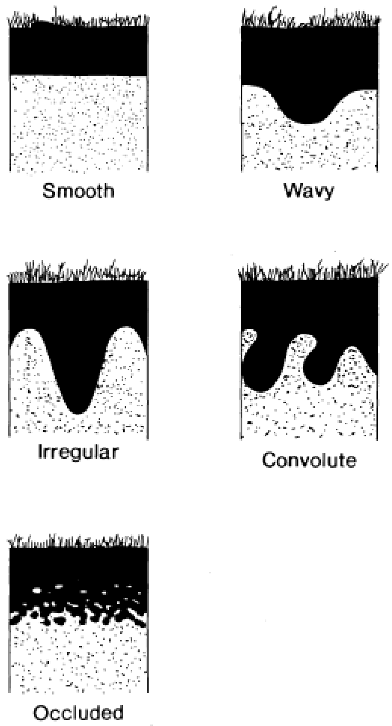


Figure 2 Visualization of horizon boundary distinctness classes (Milne et al., 1995).



Boundary topography

Determine the topography of the horizon boundaries according to Table 11 and Figure 3.

Record the corresponding codes to the scoresheet.

Table 10 Classification of horizon boundary topography (Milne et al., 1995).

TOPOGRAPHY

Code*	Class	Determination
S	Smooth	Nearly plane surface
W	Wavy	Pockets less deep than wide
I	Irregular	Pockets more deep than wide
C	Convolute	Discontinuous

** Any of the classes can be qualified by the term “occluded” if the boundary zone contains domains of upper and lower horizons. Occluded boundaries are given the topography codes **SO, WO, IO, BO**.*

Figure 3 Visualization of horizon boundary topography classes (Milne et al., 1995).

2.3 Particle size

For complete information on particle size descriptions see Milne et al. (1995) – pages 45 to 52.

Texture class

Determine the texture class for the fine-earth fraction (particles < 2mm).
Use the texture determination flow charts (Figure 5) for an initial texture class determination.
Then use the texture triangle (Figure 4) to fine tune texture class determination.
Use Table 12 to find the code coinciding to the texture class and record this into the score sheet.

- **Bolus**: handful of moistened soil able to retain its shape after moulding.
- **Polish**: smooth shiny surfaces to soil (bolus) when rubbed with a fingernail.

Table 11 Codes for texture classes (Milne et al,. 1995).

CODE	TEXTURE	TEXTURAL CLASS DEFINITION
S	Sand	>80% sand and <8% clay
LS	Loamy sand	>80% sand, <40% silt, <8% clay
SL	Sandy loam	>8% clay and <40% silt
LZ	Loamy silt	40% - 82% silt
Z	Silt	>82% silt
SCL	Sandy clay loam	<15% silt
CL	Clay loam	15% - 40% silt
ZL	Silt loam	>40% silt
LC	Loamy clay	<60% clay, <30% silt
ZC	Silty clay	<60% clay, >30% silt
C	Clay	>60% clay

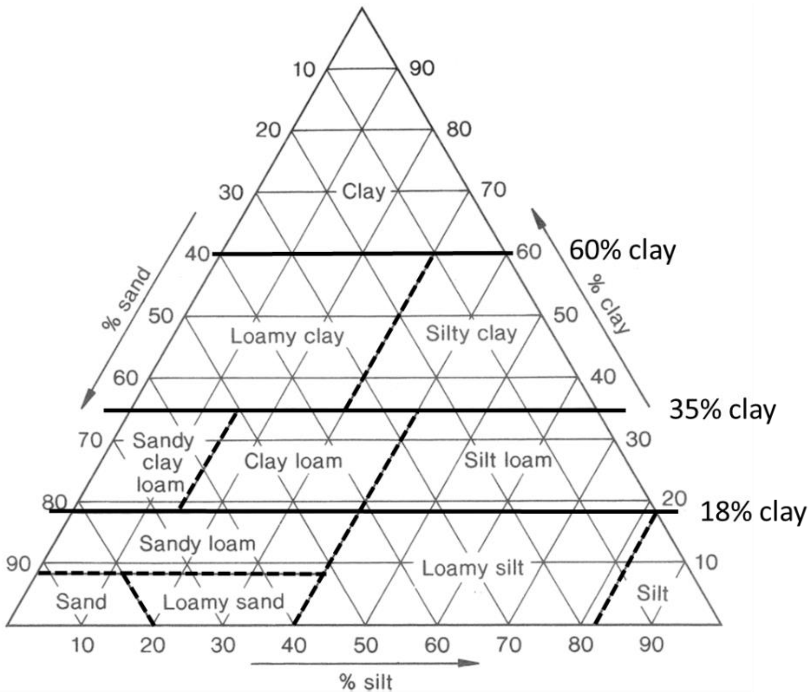


Figure 4 Soil texture triangle (Milne et al., 1995).

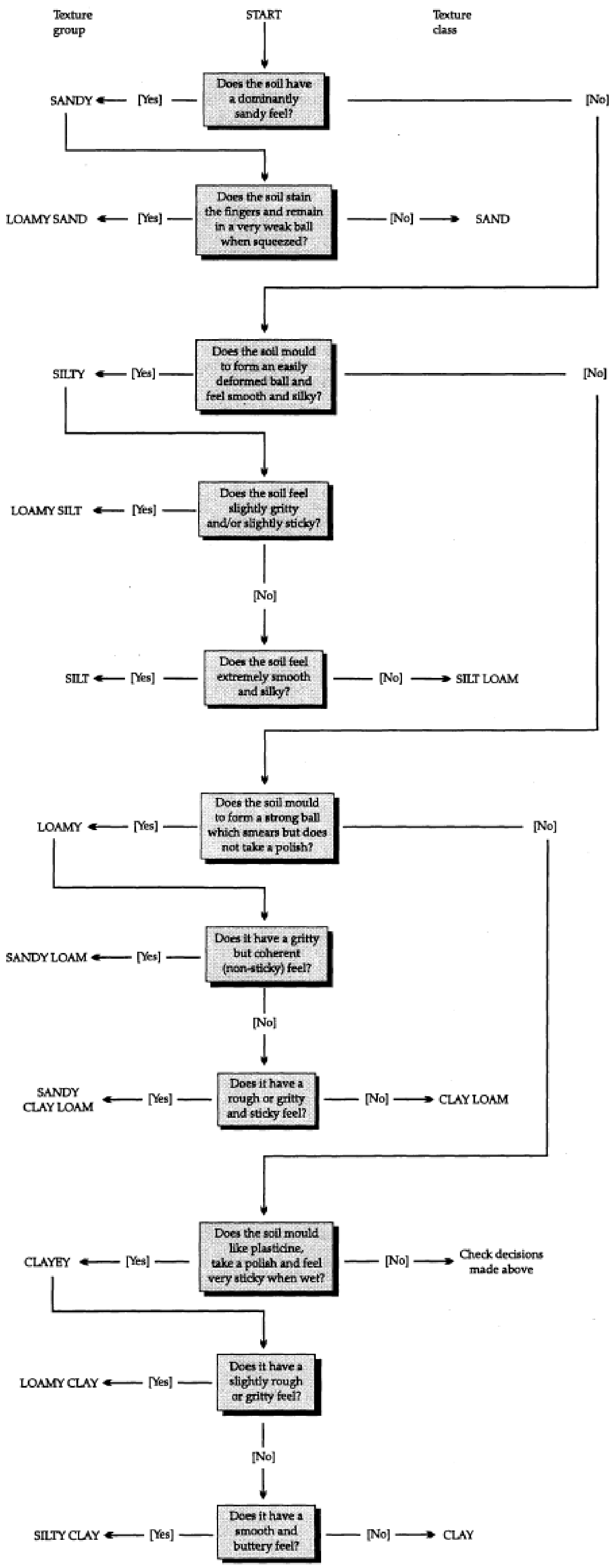


Figure 5 Flow chart for texture class determination (Milne et al., 1995).

Coarse fragments

Modifiers to the texture class according to rock fragments will depend on the abundance and dominant size of the fragments.

For soil material coarser than sand (>2mm) estimate the % volume using the abundance charts in Chapter 6 of this handbook or in Appendix 2 in Milne et al. (1995).

Note: **35%** by volume of gravel approximately represents the boundary between materials in which the gravels seem to be entirely 'floating' in the fine-earth matrix, and materials in which pieces of gravel are to some extent touching one another. **70%** by volume of gravel broadly represents the boundary beyond which individual pieces of gravel are in complete contact, and any fine-earth is confined to interstices (Milne et al., 1995).

Use Table 13 to find the corresponding abundance class code and record this on the scoresheet.

Table 12 Gravel and boulder abundance by volume (Milne et al., 1995)

CODE	ROCK FRAGMENT VOLUME %	TEXTURE MODIFIER CLASS
1	<1	Non-gravelly (stoneless*)
2	1-5	Very slightly gravelly
3	5-15	Slightly gravelly
4	15-35	Moderately gravelly
5	35-70	Very gravelly
6	>70	Extremely gravelly

Determine the dominant rock fragment size. This is the size that constitutes the greatest volume of all rock fragments in the horizon. Use Table 14 to find the corresponding size class code and record this on the scoresheet.

Table 13 Gravel and boulder size classes (Milne et al., 1995).

CODE	ROCK FRAGMENT SIZE MM	ROCK FRAGMENT SIZE CLASS
FG	2-6	Fine gravel
MG	6-20	Medium gravel
CG	20-60	Coarse gravel
VCG	60-200	Very coarse gravel
B	>200	Boulders

* If stoneless (ie 0% coarse fragments), use **X** for size class.

2.4 Structure and consistence

Soil structure is the part of the macrofabric that includes the soil aggregates and the voids between them (Hodgson, 1976 in Milne et al., 1995). It refers to the shape, size and degree of development of aggregation of the primary soil particles into structural units. Soil aggregate is a general term for any distinct lump or cluster of primary soil particles, including peds, casts, clods and fragments.

Degree of pedality

Determine whether there are aggregates.

- If not: the soil class is X, structureless.
- If yes: use Figure 6 to determine the type of aggregates in the soil and Table 15 to determine the degree of pedality.

Record the correct degree of pedality class code on the scoresheet.

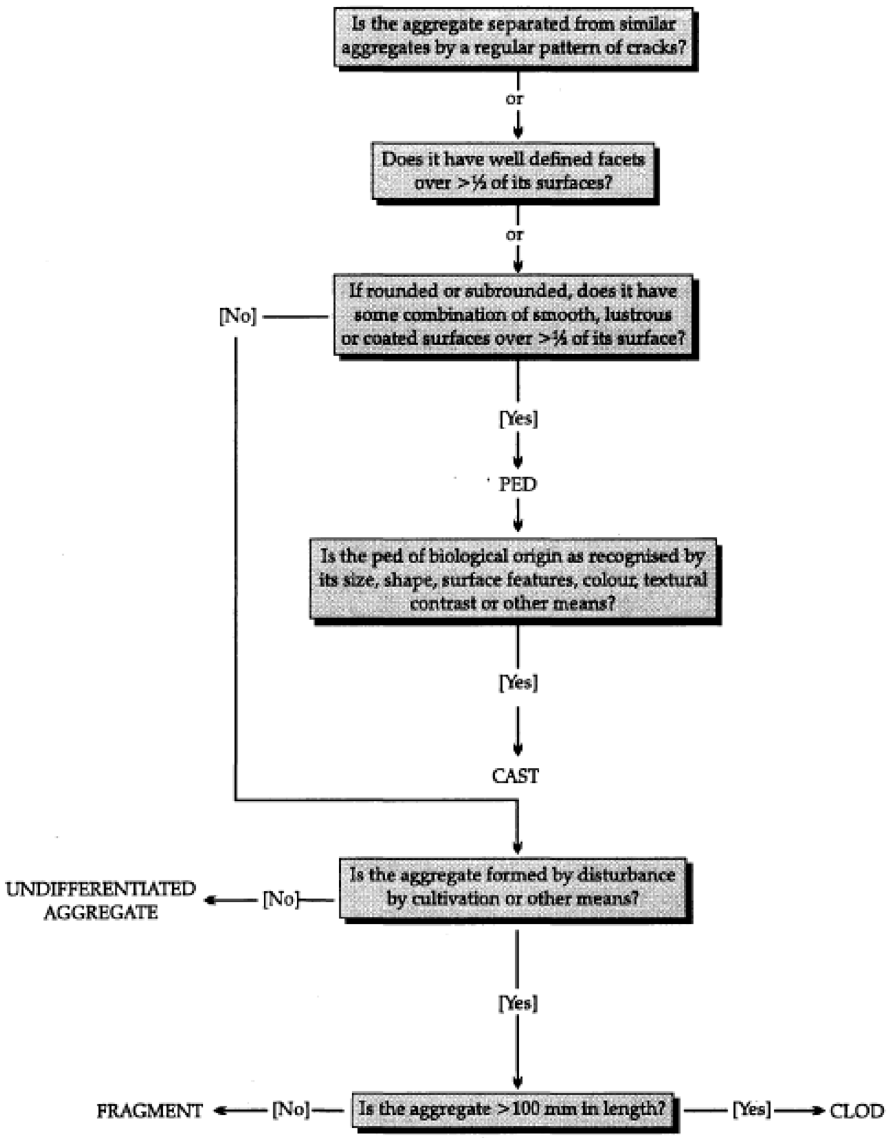


Figure 6 Flowchart for aggregate identification (Milne et al., 1995; page 59).

Table 14 Degree of pedality for soil materials (Milne et al., 1995; page 60).

CODE	CLASS	DEFINITION
X	Structureless	Apedal. Contains less than 15% in peds*.
W	Weak	Peds are barely observable in place, 15-25% in peds.
M	Moderate	Peds well-formed and evident in place, 25-75% in peds.
S	Strong	Peds are distinct in place, >75% in peds.

** Percentage by weight of fine earth soil material consisting of peds.*

Type of structureless for apedal material

If for degree of pedality the class structureless, X, has been recorded, use the flowchart in Figure 7 and Table 16 to identify the "type of structureless". Record the correct code on the scoresheet.

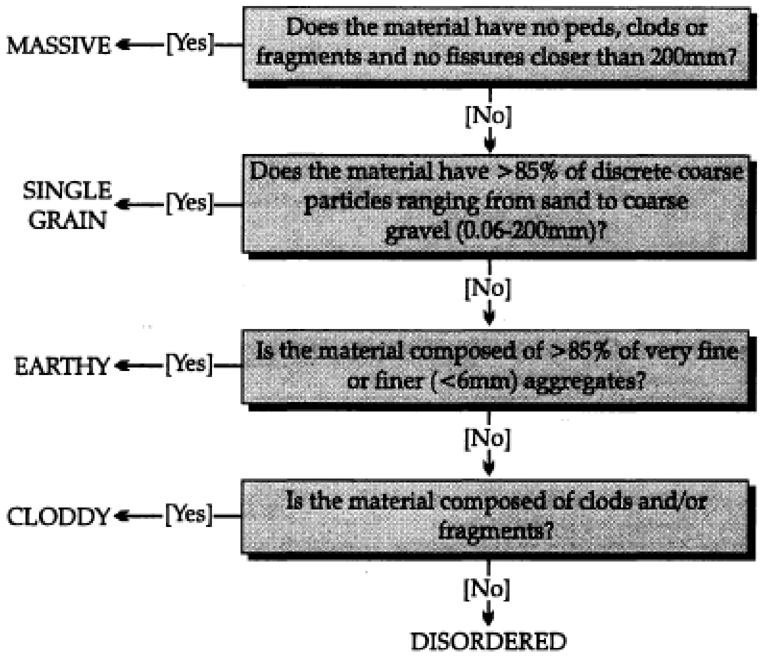


Figure 7 Flowchart for identification of apedal materials (Milne et al., 1995; page 60).

Table 15 Type of structureless for apedal materials (Milne et al., 1995; page 58).

CODE	TYPE	DEFINITION
MA	Massive	Material without peds, clods or fragments, and having no fissures at spacings of less than 200 mm.
SG	Single grain	Material with more than 85% by weight of discrete primary particles ranging in size from sand to very coarse gravel.
EA	Earthy	Material composed of more than 85% by weight of very fine or finer (< 6 mm) aggregates.
CL	Cloddy	Material formed in recently cultivated surface horizons and composed dominantly of clods and fragments.
DI	Disordered	Apedal material that does not meet the specifications of massive, single grain, earthy or cloddy.

Type of structure for pedal material

If the degree of pedality has been described as weak (W), moderate (M) or strong (S) use the Figure 8 and 9 and Table 17 to identify the type or shape of the structural units.

Shapes are identified by using the following convention (see Figure 9):

- Measure the longest axis about which the shape will rotate symmetrically.
- Measure the shortest axis at right angles to the longest axis.
- Measure the intermediate axis at right angles to the other two axes.

Ratios between these axes $\left(\frac{intermediate}{longest} \ and \ \frac{shortest}{intermediate}\right)$ are used as quantitative indicators in Table 17.

Record the correct code onto the scoresheet.

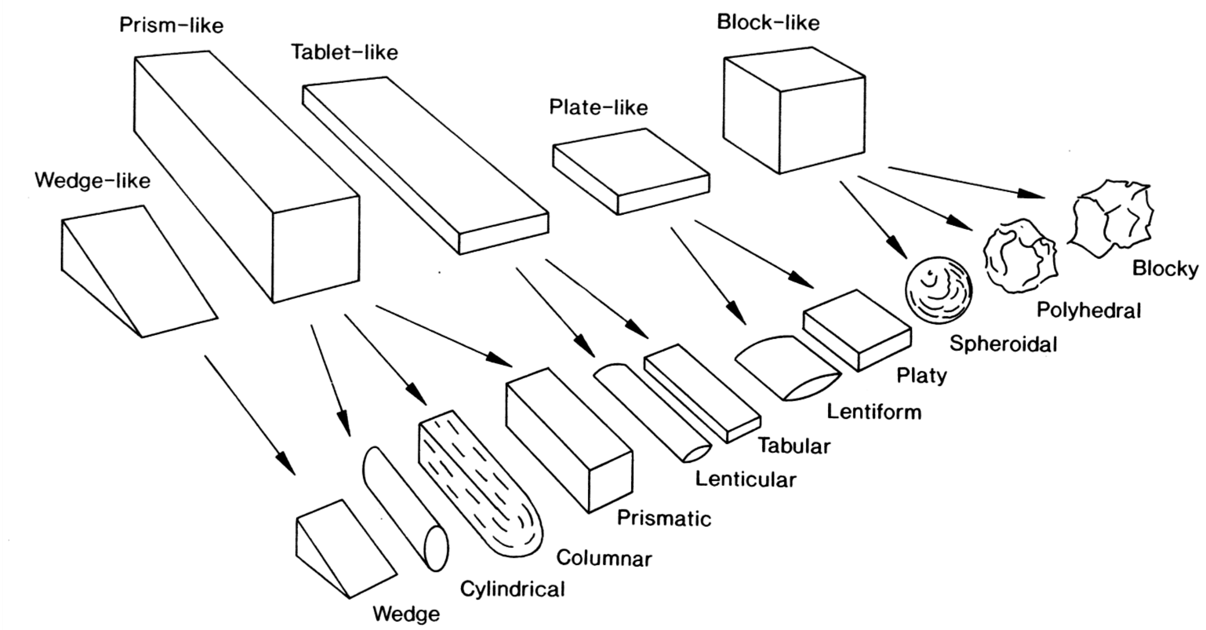


Figure 8 Simple structural shapes (Milne et al., 1995, pp 69)

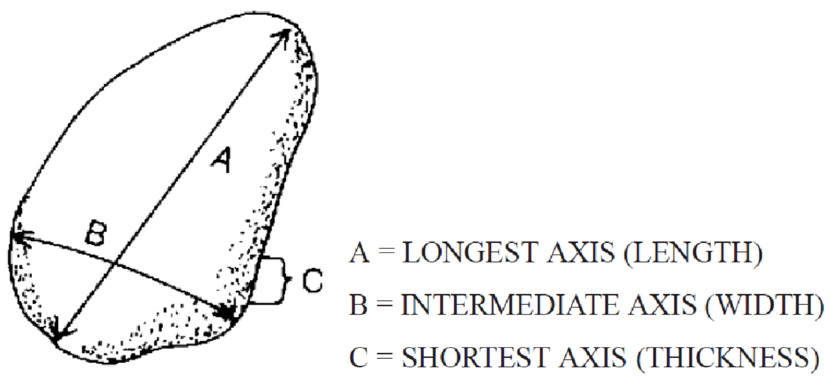


Figure 9 Image representing axes measurements in particle or aggregate (Harrelson, Rawlens and Potyondy, 1994).

Table 16 Classification of simple shapes of soil structure (from Milne et al., 1995 pp 68).

CODE	SHAPE CLASS	AXIAL RATIO $\frac{intermediate}{longest}$	$\frac{shortest}{intermediate}$	ROUNDNESS	OTHER NECESSARY PROPERTIES
			BLOCK-LIKE		
BL	Blocky	> ½	> ½	angular-subrounded	majority of angles between faces <90°
PH	Polyhedral	> ½	> ½	angular-subrounded	majority of angles between faces >90°
SR	Spheroidal	> ½	> ½	rounded	
			TABLET-LIKE		
TB	Tabular	< ½	< ½	angular-subrounded	
LT	Lenticular	< ½	< ½	rounded in cross-section	
			PRISM-LIKE		
PM	Prismatic	< ½	> ½	angular-subrounded	flat ends
CO	Columnar	< ½	> ½	angular-subrounded cross-section	multifaceted or rounded ends
CL	Cylindrical	< ½	> ½	rounded cross-section	ovate or circular cross-section
			PLATE-LIKE		
PL	Platy	> ½	< ½	angular-subrounded	
LF	Lentiform	> ½	< ½	rounded	
			WEDGE-LIKE		
WL	Wedge	no restriction	< ½	no restriction	

Size of structural units*

Determine the applicable size class(es) for structural units. Choose one (example given "2") or more classes (example given "3-5") from Table 18 and record on the scoresheet.

Table 17 Structural unit and root size classes (Milne et al., 1995).

CODE	SIZE CLASS	SIZE RANGE
1	Microfine	<1
2	Extremely fine	1-2
3	Very fine	2-6
4	Fine	6-10
5	Medium	10-20
6	Coarse	20-60
7	Very coarse	60-100

* If structureless use **X** for size class.

Consistence – Soil strength or resistance to crushing

The strengths of minimally disturbed soil samples, at field water content, are determined as the resistance to crushing of an unconfined volume of soil (Milne et al., 1995). Sampling should ideally occur on a **30mm cube sample of undisturbed soil**.

In practice, standard cube samples will include aggregates or parts of aggregates, or they will be cut from larger aggregates, and some will be cut from apedal soil materials.

For all these **apply pressure on horizontal faces of cubes** (as oriented in the profile) and use Table 19 to determine cube strength. Record the correct code on the scoresheet.

If a test specimen cannot be obtained (due to strong developed structure or in apedal material) record soil strength as very weak.

Table 18 Strength, or resistance-to-crushing, of field MOIST soil samples (Milne et al., 1995 page 83).

METHOD	CODE	CLASS	CONDITIONS OF FAILURE OF 30 MM CUBE
Force applied between extended forefinger and thumb.	1	Very weak	Fails under very gentle force
	2	Weak	Fails under gentle force
	3	Slightly firm	Fails under moderate force
	4	Firm	Fails under strong force, the maximum that most people can exert
Force applied slowly under foot on a hard flat surface or between both hands locked.	5	Very firm	Fails with gentle force under foot; can be crushed between locked hands of average person
Force applied slowly under foot on hard surface.	6	Hard	Fails under the force which is applied slowly by full body weight of ~80 kg.
	7	Very hard	Withstands the force applied slowly under foot by average body weight of ~80 kg.

Consistence - Failure type

Table 20 Failure classes for soil consistence (Milne et al., 1995 page 84).

CLASS CODE		CLASS DEFINITION
V	Very friable	Test sample cannot be formed or crumbles under very slight stress on crushing within the hand, into aggregates predominantly < 2mm in size. In most instances the test sample is difficult to obtain.
F	Friable	Test sample cannot be formed or crumbles under very slight stress, into aggregates predominantly > 2mm in size, or under slight stress into aggregates predominantly < 2mm in size
B	Brittle	Under slowly increasing pressure, the test sample retains its size and shape, with few to no cracks, until it abruptly fractures into aggregates of > 2mm in size
S	Semi-deformable	Under slowly increasing pressure, the test sample is compressible in the direction of pressure. The sample will develop cracks and/or rupture before reaching half its original thickness.
D	Deformable	Under slowly increasing pressure, the test sample is compressible in the direction of pressure, to at least half its original thickness without cracks or rupture.

2.5 Soil matrix colour

Use the Munsell Soil Color Charts to determine the primary colour, and where applicable the secondary colour, of the matrix for each horizon described. Colours must be designated by **Hue**, **Value** and **Chroma**. Record each of these on the scoresheet.

For routine descriptions, the moist colour(s) of the soil matrix should be determined out of direct sunlight and by matching the surface of a broken ped with the colour chip of the Munsell Soil Color Charts.

2.6 Redoximorphic features

Redoximorphic features are colour patterns in a soil caused by loss (depletion) or gain (concentration) of pigment compared to the matrix color; formed by oxidation/reduction of iron (Fe) and/or manganese (Mn) coupled with their removal, translocation or accrual.

Iron (Fe) or manganese (Mn) reduction occurs when free oxygen is limited or excluded from a soil volume or horizon by water saturation for extended time. Oxidized Fe will generally have a redder or yellower color than adjacent soil particles, while Mn often will have a darker color than adjacent soil particles.

Redox concentrations are defined as localized zones of enhanced pigmentation due to accrual of Fe-Mn minerals and they may be identified as:

- ***Nodules and concentrations*** – cemented bodies of Fe-Mn oxides (concentrations have internal rings and nodules do not).
- ***Mottles*** –non-cemented bodies of enhanced pigmentation that have a redder or blacker color then the adjacent matrix. (*These are termed masses in Schoeneberger et al., 2012*). [**Note**: Mottles are spots, blotches or streaks of subdominant colours different from the matrix colour and also different from the colour of the ped surface. Colour patterns due to biological or mechanical mixing, or inclusions of weathered substrate material are not considered to be mottles.]

Redox depletions are defined as zones with chromas less than 2 (they can be greyer, lighter or less red than the adjacent matrix). They may be identified as:

- ***Iron depletions*** – zones that contain lesser amounts of Fe and Mn oxides but have clay content similar to that of the adjacent matrix.
- ***Clay depletions*** – zones that contain lesser amounts of Fe, Mn, and clay compared to the adjacent matrix.

If the matrix is described as a depleted colour (with a value of ≤2) depletion should be indicated in the horizon designation, and NOT as a redoximorphic feature. Only redoximorphic concentrations should be in the redoximorphic feature column.

Type of redoximorphic features

Determine the type of redoximorphic features according to Table 20. Record the correct class code on the scoresheet.

Table 19 Types of redoximorphic features.

CLASS CODE	CLASS DEFINITION
N	No redoximorphic features.
C	Hard nodules and concentrations.
D	Iron depletions with value ≥ 4 and chroma ≤ 2. Clay depletions.
C/D	Concentrations and depletions with value ≥ 4 and chroma ≤ 2.
M	Non-cemented concentrations of reoxidised Fe and/or Mn.

Abundance of redoximorphic features

Estimate the % of redoximorphic features using the abundance charts in Chapter 6 of this handbook or in Appendix 2 in Milne et al. (1995). Use Table 21 to find the correct abundance class code and record this on the scoresheet.

If no mottles are present, indicate **N** on the scoresheet.

Table 20 Abundance of mottles (Milne et al., 1995 pp 97)

CODE	CLASS	ABUNDANCE (%)
1	Very few	<2
2	Few	2<10
3	Common	10<25
4	Many	25<50
5	Abundant	50<75
6	Profuse	>75

Contrast of mottles

Consider the most abundant redoximorphic colour and the applicable soil matrix colour to determine mottle contrast based on Table 22. Record the result on the scoresheet, if no mottles indicate **X**.

Table 21 Contrast classes of redoximorphic features.

CODE	CLASS	DEFINITION
F	Faint	Indistinct colour variation evident on close examination. Typically the mottle colour is of the same hue and will differ by no more than one unit of chroma or two units of value.
D	Distinct	Although not striking, the colour variation is readily seen. Matrix and mottle colours usually: - have the same hue but differ by 1<4* units of chroma, or 2<4 units of value. Or, - differ by 1 hue (2.5 Munsell units) and <2 units of chroma, or <3 units of value.
P	Prominent	The colour variation is conspicuous. Matrix and mottle colours usually differ by: - ≥2 hues (5 Munsell units) if chroma and value are the same. Or, - ≥4 units of value or chroma if hue is the same. Or, - ≥1 unit of chroma or ≥2 units of value if there is a difference of only 1 hue (2.5 Munsell units).

** All mathematical notation are as they stand, ie 1<4 means more than 1 and less than 4, excluding 1 and 4. In some cases this reads as there only being 1 option (ie 2<4 reads as =3), however some half units are used in the colour book and are in this way included.*

2.7 Coatings

Coatings refers to features that appear on ped and void surfaces. Determine the type of coatings based on Table 23. Record the correct code on the scoresheet. If no coatings are present, indicate **X** on the scoresheet.

Table 22 Classification of types of coatings (adapted from Milne et al., 1995 – page 74; with additions from Schoeneberger et al., 2012)

CODE	CLASS	DEFINITION
X	No coatings	
CB	Carbonate coats	They may be coats of powdery material or concentrations of larger crystals. (Mainly calcium carbonates.)
CC	Clay coats (argillans)	Waxy, exterior coats. Often different in colour from matrix. Usually recognizable in sandy/loamy soils, hard to recognize in clayey soils where they can be undistinguishable from pressure faces.
OG	Organic coats	Dark, organic stained films with a moist value of ≤4 and rich in organic matter in comparison to the interior of the coated solid.
SQ	Sesquioxide coats	Films of sesquioxides, often ferri-manganiferous coatss. Normally very dark brown or black.
SS	Slickensides	Smooth/glossy faces with linear grooves/striations on soil-structural units (peds). Caused by shrinking and swelling leading to lateral movement of adjoining peds on wetting.

2.8 Roots

Root abundance

Determine root abundance class based on Table 24. Note there are two different scales, choose the applicable one based on root size (see below).

Table 23 Root abundance classes (Milne et al., 1995 – page 65).

CODE	ABUNDANCE CLASS	NR OF ROOTS IN 10X10CM SQUARE FOR MICROFINE AND FINE	vs	VERY FINE AND LARGER
1	Few	1-10		1 or 2
2	Common	10-25		2-5
3	Many	25-200		>5
4	Abundant	>200		-

Root size

Determine the applicable size class(es) for roots. Choose one or more classes as per Table 18 and record on the scoresheet.

Use the abundance class scale for the most dominant root size (highest number in 10x10cm square).

3. Soil Profile Characteristics

For the competition the following soil profile characteristics have to be determined:

3.1 Effective soil depth and restrictive layer
3.2 Hydraulic conductivity of surface layer and restrictive layer
3.3 Available Water Holding Capacity
3.4 Soil Drainage Class

3.1 Effective soil depth and restrictive layer

Effective soil depth

Determine the effective soil depth category based on Table 25 and record the correct code on the scoresheet.

If the lower depth of judging is less than 150 cm, and there is no restricting layer within or at the judging depth, the horizon encountered at the bottom of the judged profile may be assumed to continue to at least 150 cm and 'very deep' should be selected.

Table 24 Effective soil depth classes.

CODE	CLASS	DEPTH TO RESTRICTIVE LAYER
VD	Very deep	> 150 cm
D	Deep	100 ≤ 150 cm
MD	Moderately deep	50 ≤ 100 cm
S	Shallow	20 ≤ 50 cm
VS	Very shallow	≤ 20 cm

Type of restrictive layer

Determine the type of restrictive layer based on Table 26 and record the correct code on the scoresheet.

Table 25 Type of restrictive layers.

CODE	CLASS
BR	Bedrock
CS	Structureless ZC, C or SC
CM	Massive ZC, C or SC
W	Reducing conditions or water table
IM	Impermeable Layer
N	No restrictive layer

3.2 Hydraulic Conductivity

Critical for agronomic soil functions and partitioning of rainfall, we will estimate the saturated hydraulic conductivity of the surface layer and the restrictive layer.
Based on Table 27 determine the hydraulic conductivity class of the surface layer and of the restrictive layer. Record the correct class codes (H, M or L) on the scoresheet.

Table 26 Hydraulic conductivity classes.

CODE	CLASS	DEFINITION
H	High	Includes: - All sand and loamy sand texture classes. - Sandy loam, sandy clay loam, and silt loam texture grades that are especially 'loose' because of very high organic matter content (>5% organic carbon). - Horizons containing >60% of coarse fragments with insufficient fines to fill voids between fragments are also considered to have high hydraulic conductivity.
M	Moderate	This includes those materials excluded from 'low' and 'high' classes.
L	Low	Includes: - Clays, or silty clays having structure grade of **M** or **W**; or structureless (**X**) and massive (**MA**). - Clay loams that have a structure grade of **W**; or structureless (**X**) and massive (**MA**). - Bedrock layers (Cr or R horizons) where the horizon directly above contains redoximorphic depletions or a depleted matrix due to prolonged wetness (value ≥4 with Chroma ≤2). - Bfm or Bx horizons or other restrictive pans.

3.3 Available Water-Holding Capacity (AWHC)

Critical to agronomic interpretations for crop growth, the available water-holding capacity is approximately the water held between field capacity and permanent wilting point. The approximate amount of moisture stored in the soil is calculated for the top 150 cm of the soil profile.
Determine the **available water-holding capacity** of the soil, based on the information below.

The total available water-holding capacity is calculated by summing the amount of water held in each horizon to a depth of 150cm.
If the lower depth of judging is less than 150 cm, the horizon encountered at the bottom of the judged profile may be assumed to continue to 150 cm.
If the lower depth of judging is more than 150 cm, the horizon encountered at the 150 cm marked is only taken into account up to 150 cm (ie a portion of the horizon is used in calculations).
If there is a restrictive layer, this layer and all horizons below should be excluded in calculating the available moisture.

The calculation

The relationship between available water retained per cm of soil and the texture is given in Table 28.

- Coarse fragments, for the purpose of this competition, are considered to have negligible (assume zero) moisture retention, and estimates must be adjusted to reflect the coarse fragment content. If a soil contains coarse fragments, the volume occupied by the rock fragments must be estimated and the available water holding capacity (AWHC) corrected accordingly.

Table 27 Estimated relationships between available water holding capacity by texture class.

AWHC (cm water / cm soil)	APPLICABLE TEXTURE CLASSES
0.05	S, LS
0.10	SL
0.15	SCL, CL, SC, LC, C
0.20	LZ, ZL, ZC

Example calculation:

Consider a **SILT LOAM** horizon that is **25 CM THICK** and contains **10% ROCK FRAGMENTS.**

The available water-holding capacity of the horizon would be calculated as follows:

Thickness (cm)	×	AWHC for ZL (cm/cm)	×	fine-earth fraction	
(upper – lower boundary)		*(from Table 26)*		*[(100 - % coarse fragments)/100]*	
25 cm	×	**0.20 cm/cm**	×	**[(100-10)/100]**	**= 4.50 cm**

Repeat this calculation for each subsequent horizon (rounding to 2 decimal points), up to 150cm (see notes above).

Sum AWHC of all horizons and round total AWHC (cm) to 1 decimal point.

The retention classes

Use Table 29 to determine the correct retention classes for AWHC (cm) and record the correct code on the scoresheet.

Table 28 AWHC retention classes (Csorba et al., 2015).

CODE	CLASS	PROFILE AWHC
VL	Very low	≤ 7.5 cm
L	Low	7.5 ≤ 15 cm
MO	Moderate	15 ≤ 22.5 cm
H	High	> 22.5 cm

3.4 Soil Drainage Class

Critical for understanding the effects of soil function such as flooding, partitioning of water, drainage, habitat, water purification, and construction. Soil drainage class is a reflection of the rate at which water is removed from the soil by both runoff and percolation. Landscape position, slope gradient, infiltration rate, surface runoff, and permeability, are significant factors influencing the soil drainage class. Redoximorphic features, including concentrations, depletions, and depleted matrix, are the common indicators of prolonged soil saturation and reduction (wet state), and are used to assess soil wetness class.

Use Table 30 to determine the soil drainage class and record the correct class code on the score sheet.

Table 29 Soil drainage classes (Milne et al., 1995, pp. 148-149)

CODE	CLASS	DESCRIPTIONS
WD	Well drained	- Soils that have no horizon within 90 cm of the mineral soil surface with > 2% redox segregations.
MWD	Moderately well drained	- Soils that have a horizon between 60 and 90 cm of the mineral soil surface with ≥ 50% low chroma mottles on cut faces or ped faces. OR - Soils that have a horizon between 30 and 90 cm of the mineral soil surface > 2% redox segregations.
ID	Imperfectly drained	- Soils that have between the 30 and 60 cm of the soil surface, but not within 15 cm of the base of the A horizon, ≥ 50% low chroma mottles on cut faces or ped faces. OR - Soils that have either (a) within 15 cm of the base of the A horizon, or (b) within 30 cm of the mineral soil surface: o > 2% redox segregations, or o < 50% low chroma colours on cut faces or ped faces.
PD	Poorly drained	- Soils that have a distinct topsoil (Hewitt, 2010) and that (a) within 15 cm of the base of the A horizon, or (b) within 30 cm of the mineral soil surface, that have ≥ 50% low chroma colours on cut faces or ped faces. OR - Soils that lack a distinct topsoil and have ≥ 50% low chroma colours on cut faces between 10 and 30 cm from the mineral soil surface.
VPD	Very poorly drained	- Soils that have an O horizon (but no F or H horizon) with an Er, Br, or Cr horizon immediately below. OR, - Soils that lack a distinct topsoil and have ≥ 50% low chroma colours on cut faces at > 10 cm from the mineral soil surface.

4. Interpretations

Using Tables 31, 32 and 33, respectively, determine the landscape suitability classes for (a) Irrigated Pasture, (b) Viticulture and (c) Potato Production.
Record the suitability class code (1, 2 or 3) on the scoresheet.

Steps for landscape suitability class determination:

1. Start in the right-hand column of the tables.
2. Read down the right-hand column, checking the criteria.
   a. If one factor is met in the right-hand column, the suitability class is Unsuitable (Code 3).
   b. If none are met, move one column to the left.
3. Read down the middle column, checking the criteria.
   a. If one factor is met in the middle column (after the right-hand column has been checked), the suitability class is Suitable (Code 2).
   b. If none are met, move one more column to the left.
4. If none of the criteria are met in either the right-hand or middle column, the suitability class is Optimal (Code 1).

Table 30 Criteria for irrigated pasture land use

FACTORS	**LAND SUITABILITY RATINGS**		
	CLASS 1 – OPTIMAL	**CLASS 2 – SUITABLE**	**CLASS 3 - UNSUITABLE**
Slope class	01, 02, 03, 04, 05	06	07, 08, 09
Drainage class	WD / MWD	ID	PD / VPD
Erosion degree	None, S	M	V, E
Topsoil depth (cm)	>10	<10	-
Texture class in thickest horizon in upper 20 cm	SL, SCL	Others	S, C
Depth to hard rock (cm)	>60	45<60	<45
Soil pH	6.0<7.0	5.0<6.0; 7.0<7.5	<5.0 / >7.5
Hydraulic conductivity restrictive layer	H	M	L
AWHC to 100cm	>15	5<15	<5

Table 31 Criteria for viticulture land use

FACTORS	LAND SUITABILITY RATINGS		
	CLASS 1 – OPTIMAL	CLASS 2 – SUITABLE	CLASS 3 - UNSUITABLE
Slope class	05	01, 02, 03, 04, 06	07, 08, 09
Drainage class	WD / MWD	ID	PD / VPD
Erosion degree	None, S	M	V, E
Topsoil depth (cm)	>10	<10	-
Texture class in thickest horizon in upper 20 cm	SL, SCL	Others	S, C
Depth to restrictive layer (cm)	>100	80<100	<80
Soil pH	6.0<7.0	5.0<6.0; 7.0<7.5	<5.0 / >7.5
Hydraulic conductivity restrictive layer	H	M	L
AWHC to 100cm	>15	5<15	<5

Table 32 Criteria for potato production land use

FACTORS	LAND SUITABILITY RATINGS		
	CLASS 1 – OPTIMAL	CLASS 2 – SUITABLE	CLASS 3 - UNSUITABLE
Slope class	01, 02, 03	04, 05, 06	07, 08, 09
Drainage class	WD / MWD	ID	PD / VPD
Erosion degree	None, S	M	V, E
Texture class in thickest horizon in upper 20 cm	S, LS, SL, L	Zl, Z, CL, SCL	SC, ZC, C
Depth to root restriction or abrupt textural change (cm)	>50	20<50	<20
Hydraulic conductivity restrictive layer	H	M	L
Soil pH in thickest horizon in upper 20 cm	5.0<5.5	5.5<7.0	<5.0 / >7.0

5. Diagnostic Criteria and Soil Classification

Note: Chemical and physical data necessary for the classification will be provided at each pit.

The New Zealand Soil Classification (NZSC; Hewitt, 2010) is a hierarchical classification, based on measureable soil properties which allow (where possible) the field assignment of soils to classes – either directly or by tested inferences. At its highest level, the NZSC is divided into 15 soil orders, and further divided into groups and sub-groups. These levels are equivalent to order, suborder and great group levels of both the US Soil Taxonomy and Australian Soil Classification schemes. The NZSC sub-groups can be further divided into soil families and soil siblings; however these divisions will not be used in this competition.

5.1 Diagnostic Criteria

Horizons, pans, layers and features; soil material, contacts and profile forms.

On the task sheet clearly circle ALL the diagnostic horizons, pans, layers and features applicable to the profile within the specified description depth. For detailed information on the diagnostic horizons and other differentiae see pages 15-34 of the New Zealand Soil Classification, 3rd Edition (Hewitt, 2010).

5.2 Soil classification

Order

Use pages 35-40 of the Key to Soil Orders in the New Zealand Soil Classification, 3rd Edition (Hewitt, 2010) to determine ONE correct soil ORDER. Record this on the scoresheet.

Group

Using the pages applicable for groups within the selected order determine ONE correct GROUP. Record this on the scoresheet.

Subgroup

Using the pages applicable for subgroups within the selected order and group determine ONE correct SUBGROUP. Record this on the scoresheet.

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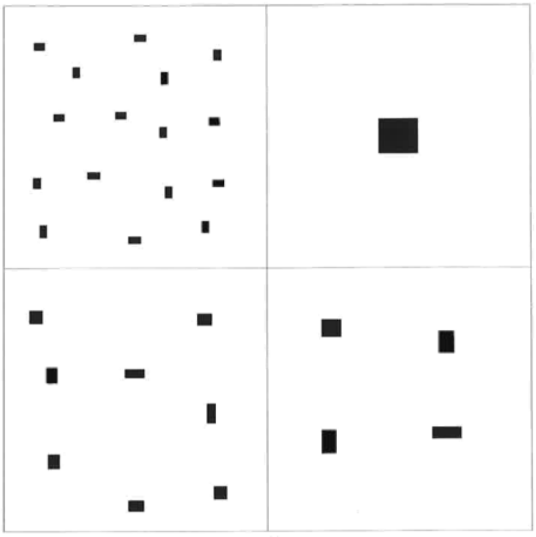
6. Abundance charts



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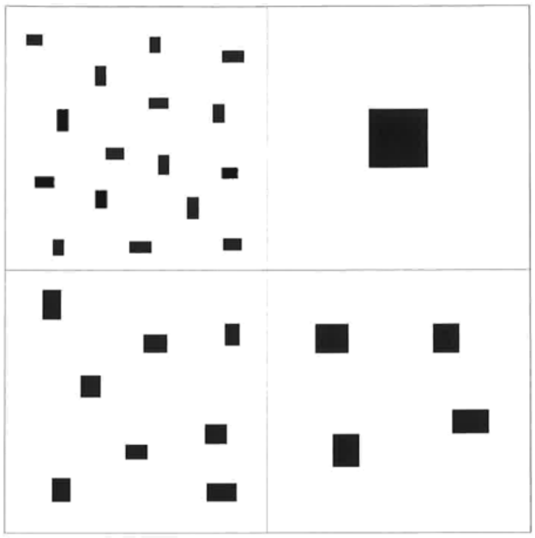

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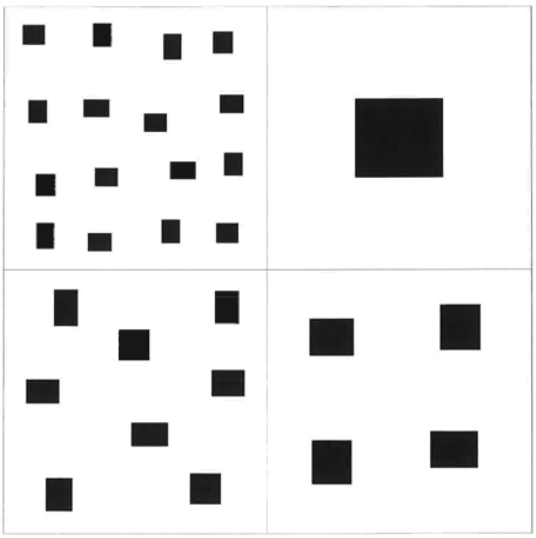

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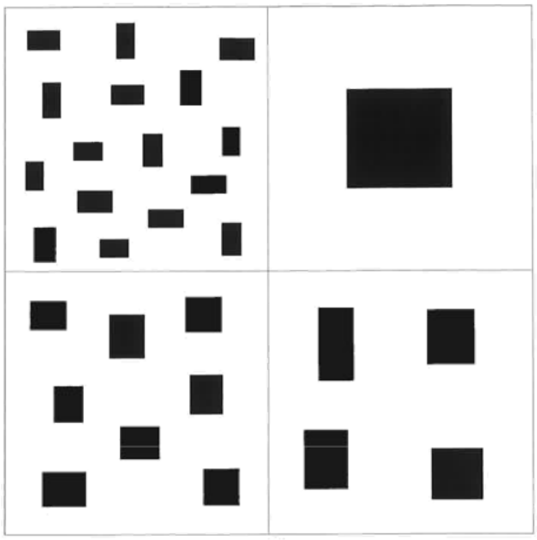

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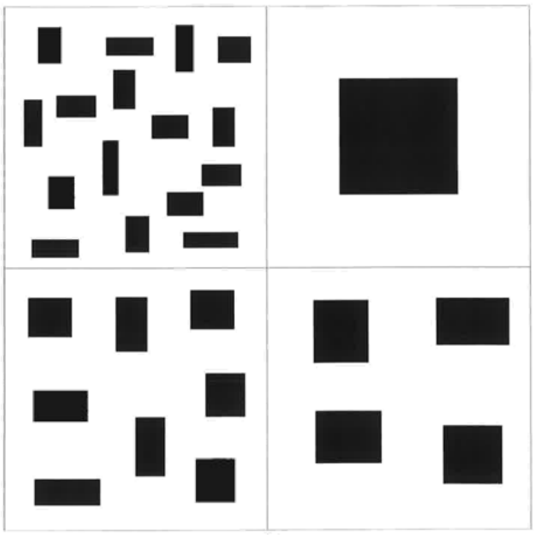

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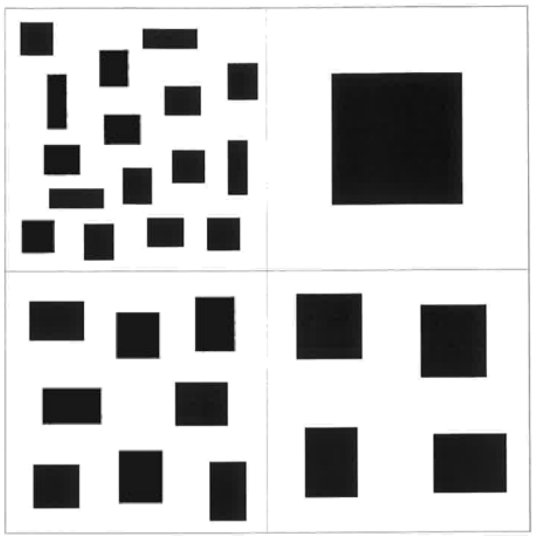

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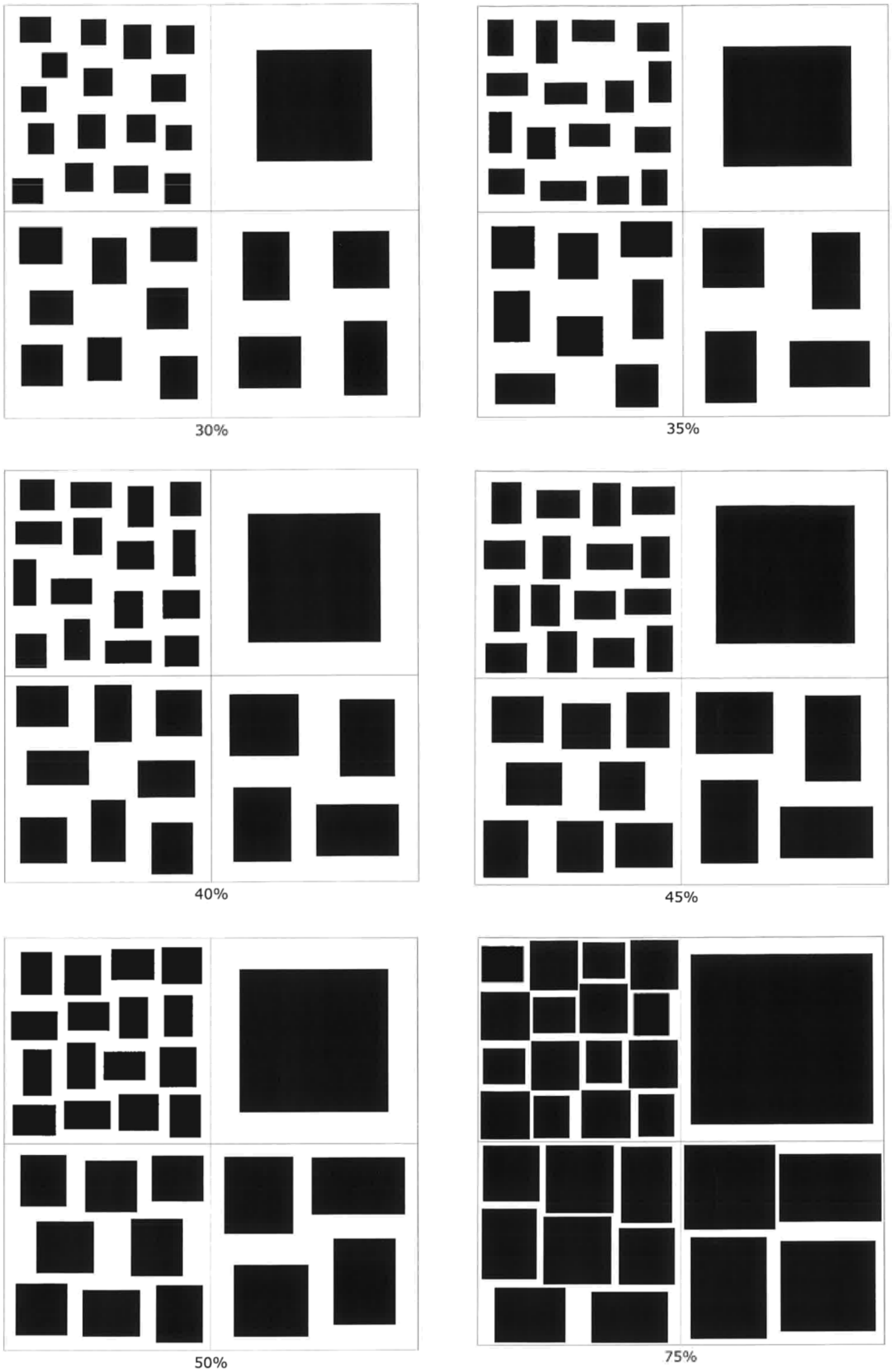

Figure 10 Abundance charts (Schoeneberger et al., 2012).

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7. References

Azam, G., Betti, G., Clark, G., Weatherley, T., and Cattle, S (2015). Australian Soil Judging Competition Handbook. September 5-6, 2015. Perth, Western Australian.

Csorba, Á., Michéli, E., Szegi, T., Láng, V., Levine, M. J., Galbraith, J. Official Handbook of the International Year of Soils (IYS) 2015 Field Course and Soil Judging Contest. September 1-5, 2015. Gödöllö, Hungary.

FAO (2006): Guidelines for Soil Description. Food and Agriculture Organization of the United Nations, Rome

Harrelson, C.C., Rawlins, C.L. and Potyondy, J.P., 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, Colorado: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Hewitt, 2010. New Zealand Soil Classification, 3rd Edition, Landcare Research Science Series No. 1, Manaaki Whenua Press, Lincoln, Canterbury, New Zealand.

Hodgson, J.M., 1976. Soil survey field handbook. Soil Survey Technical Monograph 5, Rothamsted Experimental Station 99p.

Milne, J. D. G., Clayden, B., Singleton, P. L., and Wilson, A. D. 1995. Soil: Description Handbook. Revised Edition. Manaaki Whenua Press, Lincoln, Canterbury, New Zealand.

Munsell Color Company, 1975: Munsell soil color charts. Munsell Color Company, Baltimore, Maryland, U.S.A.

Schoeneberger, P. J., Wysocki D. A., Benham, E. C., Soil Survey Staff (2012): Field Book for describing and sampling soils, Version 3.0., National Resources Conservation Service, National Soil Survey Center, Lincoln, NE. Available online here. [Accessed 6 September 2016]