Working Paper and Preprint

No. 86/3

CLASS LIMITS FOR LAND AND SOIL PROPERTIES

A comparative literature study for use at the establishment of a World Soil and Terrain Digital Database (SOTER)

Draft, for discussion and completion

A.W. Vogel

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ISRIC

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

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International Soil Reference and Information Centre
Wageningen, The Netherlands

Acknowledgement

This paper is an account of a literature study carried out for the International Society of Soil Science (ISSS), in the period april to july 1986.

Since its beginning the ISSS has initiated and implemented activities in support of improving the inventory of world soil resources. Todate, a Working Group of the ISSS is closely involved in the planning of a World Soils & Terrain Digital Database (SOTER). The present paper is meant as background information for the establishment of class limits for the soil attributes to be taken into account for the Database.

Herewith I like to express my thanks to Messrs. W.G. Sombroek and E.J. van Waveren of the International Soil Reference and Information Centre, for their valuable comments and suggestions. Without their help it would have been impossible to complete this study in such a comprehensive way.

As to the preparation of the present text I am grateful to Ms. M.B. Clabaut, who did the typing of this paper.

Wageningen, 10-07-86
A.W. Vogel

Contents

1 Introduction

In 1974 the first FAO-Unesco soil map of the world (scale 1:5 Million) was published. It was a compilation of all soil survey information that was available at that time. In the meantime countries have embarked upon systematic soil resources mapping at national scale and have recorded their growing knowledge in national geographical data sets and soil description systems. One of the major obstacles to exchange all this new information is the lack of standardization in describing and recording data. Therefore there is an urgent need to collate and correlate these national and regional geographical soil data and to bring them under a common denominator.

It looks like if SOTER is going to be the answer to this demand. This World Soils and Terrain Digital Database, which is still in a stage of development will have the following characteristics (Sombroek, 1986 a):

1 a flexible scale, however the average will be 1:1 Million.
2 compatible with data bases of other environmental resources
3 amenable to updating
4 accessible to international, regional and national decision- and policy-makers responsible for the development, management and conservation of environmental resources.

One of the first tasks to be undertaken in the early stages of the SOTER project, is the development of a universal soils and terrain mapping legend, which can accomodate all major (national) classification systems. Besides, the definition and selection of attributes to be entered into the database, needs a lot of attention.

Both aspects are elaborated in this study, by giving a review of collected literature, which can be used for SOTER in order to construct a definitive legend.

2 Methodology

2.1 Hierarchy within the database

A hierarchical system of the soil and terrain database has already been proposed (Sombroek, 1986). This means that various entries of the base structure ("legend") at a different level can be recognized. The major entry within the legend corresponds to the highest level (A). The different legend levels are:

A Physiography
B Regional parent material and parent rock
C Regional climate
D Regional vegetation / land use
E Soil profile site
F Individual soil horizons
G Substrate material
H Diagnostic soil properties

In the present paper most attention is paid to level E and F: the soil profile site and the individual soil horizons. At the same time other studies are made to describe and code the physiography (level A) and the regional parent material and parent rock (level B).

Independantly of this hierarchy some other parameters can be identified to build up the legend, namely the land qualities, also called compound properties. The way the distinguished land qualities of this study are related to the different properties is explained in chapter 3.

2.2 Land and soil properties

Each legend level is described by different land and/or soil properties. For instance, the substrate material (level G) comprises the properties grain size, porosity, strength, mineral composition, lithology and alteration.

According to the "Framework for land evalutation" (FAO, 1976) a property or characteristic is an attribute of land that can be measured or estimated. This implies that there is often a unit in which the property can be expressed. Such a quantification has as an advantage that the result is rather objective, complete and clear.

If properties are employed directly in land evaluation studies or suitability classifications, problems arise from the interaction between properties. Therefore it is recommended that the comparison of land with land use should be carried out in terms of land qualities. A land quality is a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use (FAO, 1976).

A problem is caused by those properties that have to be observed over periods of time. e.g. soil temperature, soil moisture content. They behave in a dynamical way throughout the year, so the final result is a kind of summary. (Beek et al, 1979; Haans, 1979).

Most of the properties based on soil physics and soil chemistry are derived from the standard laboratory analyses employed to characterize soil mapping units. Such data need to be treated with caution for two reasons: the high variability of physical and chemical properties within a soil type and the use of different analytical methods (FAO, 1983).

As already been stated, many national geographical data sets and soil description systems do already exist. For this study as much as possible different sets and systems were collected and compared to each other. As a starting point the properties out of which each system is built up, have been chosen, because properties are the key to the different legend levels. A comparative review of all properties is given in section 3.2.

In view of the fact that the study time was restricted, the information collection was stopped at a certain moment. Therefore, this study has not the pretention to be complete and for that reason it is called a discussion paper. Indoubtedly more national/local systems or methods exist, that are not dealt with.

2.3 Existing and proposed class groupings

If all of the words of each property were transcribed directly into the SOTER database a very large number of letters and digits would be required for each record. Since the cost of converting and storing data is proportional to the volume considerable saving can be effected by minimizing this volume. The most obvious way to achieve this is by coding as much data as possible (FAO, 1986). In this report, matters haven't gone so far as that yet. Only each property has been indicated by a combination of a letter and a number. The letter refers to the level of the legend (A until H), the number to the property itself, as well as a further subdivision of the property.

For interpretative purposes the value of all the properties should be presented as estimates within a limited number of classes (class-ratings or -groupings), rather than as actual figures of field and laboratory analysis.

It has become clear that the limits of a particular class are different in the various systems and databases studied. In some cases this results in more than 20 ways of grouping. E.g. many of the slope limits are related to erosion risk; erosion is however less of a problem in for instance Britain, and the slope limits there are set according to the feasibility of using agricultural machinery rather than on erosion hazard. On the other hand for a few properties it has been impossible to find any form of class grouping in the available literature.

Besides making a review of already existing class groupings, an important aim of this study was to stimulate the discussion on the definitive selection of one particular way of grouping, one that is universally acceptable and suitable for application in the legend of the SOTER database. So in this paper room is left to add a final proposal, that might be an already existing grouping, a completely new, or a compromise one.

3 Described and rated properties

3.1 The table-concept

In this chapter an extensive list is given of all those properties that can be distinguished at the different legend levels. Many properties can be further subdivided, e.g. surface stoniness (E2) can be separated into the abundance (E2.1), the size (E2.2) and the shape (E2.3) of the stones on the surface.

A list of land qualities related to land productivity for three kinds of land use and to management and inputs is included. Most of the land qualities are described by means of properties. Behind each quality, therefore, those properties are indicated which have an influence on it.

In the second part of this chapter, those properties which are related to the soil profile site or the individual soil horizons (level E and F) are separately presented in a table form. In most cases also a definition is given.

On the horizontal axis of each table all collected references are indicated by a number. The numbers correspond to a literature reference at the foot of each table. For a few properties it was impossible to find any form of reference.

On the vertical axis the classes are reproduced. The maximum number of classes is 12, so when in literature a grouping with more than 12 classes is given, this reference is left out of consideration. In each table, room is also left for a class grouping proposal.

3.2 Listing of all studied properties and qualities

Hierarchy:
A. Physiography
B. Regional parent material and parent rock
C. Regional climate
D. Regional vegetation/land use
E. Soil profile site
F. Individual soil horizons
G. Substrate material
H. Diagnostic soil properties

Land qualities/compound properties:
I. Land qualities related to productivity from crops or other plant growth
II. Land qualities related to domestic animal productivity
III. Land qualities related to forest productivity
IV. Land qualities related to management and inputs

A. Physiography (McDonald et al, 1984; FAO, 1977; Soil Conservation Service, 1979)

1. Regional physiography
2. Local landform
   2.1 physiographic position of the site
   2.2 topography of the surrounding country
3. Mode of geomorphological activity
4. Status of geomorphological activity
5. Geomorphological agent
6. Slope on which profile is sited
   6.1 length
   6.2 gradient
   6.3 form
   6.4 pattern
   6.5 aspect
   6.6 exposition
7. Elevation
   7.1 median
   7.2 range

B. Regional parent material and parent rock (Soil Conservation Service, 1979, Spaargaren, 1980).

1. Depth (below soil cover)
2. Parent material
   2.1 origin or source
   2.2 mode of accumulation or deposition
   2.3 texture
3. Weathering
   3.1 degree
   3.2 resistance
4. Bedrock inclination
   4.1 degree
   4.2 direction
5. Bedrock fracturing
6. Mineralogy
   6.1 abundance
   6.2 size
   6.3 form
7. Geological formation

C. Regional climate (FAO, 1983; McRae and Burnham, 1981)

1. Short-wave radiation
2. Sunshine hours
3. Daylength
4. Air temperature
5. Frost incidence
6. Rainfall
   - 6.1 amount
   - 6.2 timing (distribution)
   - 6.3 intensity
7. Rainfall aggressivity
8. Storm incidence
9. Evapotranspiration
   - 9.1 actual
   - 9.2 potential
   - 9.3 deficit
10. Moisture surplus/deficit
11. Length of humid/dry seasons
12. Incidence of dry periods
13. Relative humidity
14. Wind speed & direction
15. Hail/snow
16. Soil temperature
17. Soil temperature regime
18. Soil moisture regime
19. Climate classification

D. Regional vegetation/land use (v.Waveren, 1986 and McDonald et al, 1984).

1. Floristic composition (presence or absence of species)
2. Vegetation type
3. Vegetation status
4. Dominant specie(s)
5. Vegetation structure/physiognomy
   - 5.1 spacing (folliage cover or crown seperation)
   - 5.2 growth form
   - 5.3 height
6. Land utilization type
7. Crops
8. Rotation
9. Irrigation
10. Other improvements
11. Agro-ecological classification

E. Soil profile site

Surface characteristics

1. Microrelief
   - 1.1 height
   - 1.2 density
   - 1.3 kind
   - 1.4 pattern
2. Surface stoniness
   - 2.1 abundance
   - 2.2 size
   - 2.3 shape
3. Rock outcrops

4. Surface sealing and crusting
   4.1 degree
   4.2 thickness
   4.3 induration
5. Surface cracking
   5.1 wide
   5.2 depth
   5.3 spacing

Hydrology

6. Water table
   6.1 depth
   6.2 kind
7. Inundation
   7.1 frequency
   7.2 duration
   7.3 depth
   7.4 water quality
8. Surface run-off
9. Internal drainage
   9.1 permeability
   9.2 drainage class
10. Moisture condition
11. Water-retention difference

Transport processes

12. Actual water erosion
13. Actual wind erosion
14. Aggradation
15. Mass movements

Miscellaneous information

16. Effective soil depth
17. Depth of regolith

F. Individual soil horizons

1. Depth of horizon
   1.1 upper limit
   1.2 lower limit
2. Nature of boundary with horizon below
   2.1 distinction
   2.2 topography
3. Colour (dry/moist)
   3.1 hue
   3.2 value
   3.3 chroma
4. Mottles
   4.1 abundance
   4.2 size
   4.3 contrast between mottles
   4.4 sharpness mottle boundaries
5. Particle size
   5.1 grade
   5.2 distribution
   5.3 class

6. Stoniness in the profile
   - 6.1 abundance
   - 6.2 size
   - 6.3 degree of weathering
7. Structure
   - 7.1 grade
   - 7.2 type
   - 7.3 size
8. Surface features
   - 8.1 abundance
   - 8.2 thickness
   - 8.3 continuity
   - 8.4 distinctness
   - 8.5 type
   - 8.6 location
9. Porosity
   - 9.1 abundance
   - 9.2 size
   - 9.3 continuity
   - 9.4 orientation
   - 9.5 distribution
   - 9.6 morphology
   - 9.7 type
10. Fissures
    - 10.1 abundance
    - 10.2 width
11. Shrink-swell potential
12. Consistence
    - 12.1 stickiness
    - 12.2 plasticity
    - 12.3 friability
    - 12.4 fragility
    - 12.5 smeariness
    - 12.6 fluidity
13. Concentrations within the matrix
    - 13.1 abundance
    - 13.2 size
    - 13.3 hardness
    - 13.4 shape
    - 13.5 type
    - 13.6 composition
14. Cementation
    - 14.1 degree
    - 14.2 extent
15. Cemented pans
    - 15.1 continuity
    - 15.2 structure
    - 15.3 cementation
    - 15.4 type
16. Roots
    - 16.1 abundance
    - 16.2 size
    - 16.3 orientation
    - 16.4 distribution
17. Effervescence
    - 17.1 degree
    - 17.2 location

18. Acidity
    18.1 pH H_2O
    18.2 pH KCl
19. Bulk density
20. Organic matter
    20.1 abundance
    20.2 kind
    20.3 decomposition
21. Organic carbon
22. Nitrogen
23. C/N ratio
24. Salinity
25. Sodicity
26. Exchangeable Sodium Percentage
27. Carbonates
28. Gypsum
29. Cation Exchange Capacity
    29.1 CEC soil
    29.2 CEC clay
30. Anion Exchange Capacity
31. Base saturation
32. Exchangeable Calcium
33. Exchangeable Magnesium
34. Exchangeable Potassium
35. Exchangeable Sodium
36. Exchangeable Aluminium
37. Available phosphorus
38. Toxic constituents

G. Substrate material (McDonald et al, 1984)

1. Grain size
2. Porosity
3. Strength/Consistence
4. Mineral composition
5. Lithology
6. Alteration

H. Diagnostic soil properties (FAO, 1985 and USDA, 1976)

1. Abrupt textural change
2. Albic material
3. Andic soil material
4. Ferralic properties
5. Ferric properties
6. Fluvic properties
7. High salinity --► F28
8. Hydromorphic properties --► F9
9. Interfingering
10. Organic soil materials --► F24
11. Permafrost
12. Plinthite
13. Slickensides --► F12
14. Smeary consistence --► F16.5
15. Soft powdery lime --► F31
16. Sulfidic materials.
17. Takyric features --► E11

18. Tonguing
19. Vertic properties
20 Weatherable minerals --► F44
21. Amorphous material dominant in the exchange complex
22. Coefficient of linear extensibility, COLE --► F15
23. Durinodes
24. Gilgai --► E1.3
25. Lithic contact --► F3
26. Mottles that have chroma of 2 or less --► F5
27. n value
28. Paralithic contact
29. Petroferric contact
30. Sequium
31. Soil moisture regimes --► C17
32. Soil temperature regimes --► C18
33. Thixotropy --► F16.5

Land qualities/compound properties (FAO, 1976 & 1983; McRae et al, 1981) (Behind each quality the code of those properties are given which may be employed to assess the quality concerned).

I. Land qualities related to productivity from crops or other plant growth

1. Radiation regime	A6, C1, C2, C3, C19
2. Temperature regime	A6, A7, C4, C16, C17, C19
3. Moisture availability	A6, B1, C4, C6, C9, C10, C11, C12, C18, D8, E6, E10, E11, E16, F5, F7
4. Oxygen availability to roots	A6, D9, E6, E7, E9, E16, F4, F5
5. Nutrient availability	B6, E14, F18, F20, F21, F22, F23, F31, F32, F33, F34, F35, F37
6. Nutrient retention capacity	C6, D7, F5, F20, F21, F29, F31
7. Rooting conditions	B1, E16, F5, F6, F7, F9, F12, F14 F15, F19
8. Conditions affecting germination or establishment	B1, C4, C16, E4, F5, F7, F12
9. Air humidity as affecting plant growth	C13
10. Conditions for ripening of crops	A6, C4, C6, C13
11. Flood hazard	C6, E7, E8
12. Climatic hazards affecting plant growth	A6, A7, C5, C8, C14, C15
13. Excess of salts	C5, C6, E6, E9, F18, F24, F25, F26
14. Soil toxicities	F18, F27, F28, F38
15. Pest and diseases related to the land	C6, C13, D1, F5, F18
16. Soil workability	C4, F5, F6, F7, F12
17. Conditions for land preparation or clearance	A6, D1, E1, E2, E3
18. Erosion hazard	A4, A6, C6, C7, C14, D1, D4, E9, E12 E13, F5, F7, F9, F12, F14, F15, F19
19. Soil degradation hazard	E4, E9, F5, F7, F9, F12, F20, F21

II. Land qualities related to domestic animal productivity

20. Productivity of grazing land	(a resultant of many qualities listed under I)
21. Climatic hardhips affecting animals	C5, C6, C7, C8, C15
22. Endemic pests and diseases	C6, C13
23. Nutritive value of grazing land	B6, E9, E16, F5, F18, F29, F30
24. Toxicity of grazing land	F38
25. Availibility of drinking water	C5, C6, C10, C11, E6, E7, E8
26. Resistance to soil erosion under grazing conditions	A6, D1, D2, E9, E12
27. Resistance to degradation of vegetation	C10, D1, D2

III. Land qualities related to forest productivity

28. Mean annual increment of timber species	(a resultant of many qualities listed under I)
29. Types and quanties of indigenous timber species	D1, D2, D3
30. Site factors affecting establishment of young trees	E6, F5
31. Pest and diseases	C4, C13, D1, D3, F18
32. Climatic hazards - fire	C6, C9, C11
- frost	A7, C5, C15
- wind	A6, C8, C14
33. Erosion hazard	A4, A6, C6, C7, C14, D1, E9, E12, E13, F5, F7, F9, F12, F14, F15, F19
34. Tolerance to vegetation degradation	D2, D4

IV. Land qualities related to management and inputs

35. Potential for mechanization	A6, E1, E2, E3, F5
36. Conditions for storage and processing	C6, C13, F5, F6
37. Conditions affecting timing of production	C2, C4, C5, C11, C16
38. Access within the production unit	A6, F5
39. Size of potential management units	A6, F6
40. Location in relation to markets and supplies of inputs	A6

3.3 A review in table form.

E1.1 Microrelief-height (cm).

Definition: micro-relief is characterized by relief irregularities and undulations found within less than 100 m distance and not due to active erosion by win or water, e.g. termite mounds, gilgai, etc. (Van de Weg, 1978).

Reference Classes	1*	2*	3*	4	5	6	7	8	9	10	Proposal
1	0-15	0-15	-	minimal	0-15						
2	15-30 2-10%	15-30 2-10%	30-100 >7m apart	< 20	15-30						
3	30-60 10-20%	30-60 10-40%	30-100 3-7m apart	20-50	30-60						
4	>60 20-40%	>60 >40%	30-100 1-3m apart	50-100	60-100						
5	- >40%		30-100 0.3-1m apart								
6			>100 >3m apart								
7			>100 <3m apart								
8											
9											
10											
11											
12											

1*, 2*, 3* height is connected to distance

References:

1 Sombroek (1986)

2 Van de Weg (1978)

3 Day (1983); Maignien (1980)

4 Soil Conservation Service (1979)

5 Spaargaren (1980)

6

7

8

9

10

E1.2 Microrelief-density (%).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<2	-									
2	2-10	2-10									
3	10-40	10-20									
4	>40	20-40									
5		>40									
6											
7											
8											
9											
10											
11											
12											

References:

1 Spaargaren (1980); van de Weg (1978)

2 Sombroek (1986)

3

4

5

6

7

8

9

10

E1.3 Microrelief - kind.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	micro-depression	dimples	gilgai	smooth							
2	tree-throw feature	coppice mounds	hummocky	channels							
3	frost polygon	frost polygons	biotic	hogwallows							
4	gilgai	mounds	other	low hummocks							
5	land leveled	gilgai		high hummocks							
6	mounds	animal tracks		dunes							
7	raised-bog	slick spots									
8	terracettes	terracettes									
9	other	ripples									
10		galleries and holes									
11		micro-dissections									
12		cracks									

References:

1 Soil Conservation Service (1979)

2 FAO (1986)

3 Mc Donald et al (1984)

4 Mc Rae et al (1981)

5

6

7

8

9

10

E1.4 Microrelief-pattern.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	none	isolated	closed								
2	linear	linear	network								
3	closed depressions	reticulate	linear								
4	reticulate										
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1979)

2 FAO (1986)

3 Soil Conservation Service (1981)

4

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10

E2.1 Surface stoniness-abundance (%).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 0.01	< 0.01 (>25m ap.)	0-2	0-2	< 0.1	< 2	< 5	< 0.01 (>25m ap.)	0		
2	0.01-0.1 (10-30m ap.)	0.01-0.1 (8-25m ap.)	2-15	2-15	0.1-3	2-10	5-15	0.01-0.1 (8-25m ap.)	0.01-0.1 (10-30m ap.)		
3	0.1-3 (1.5-10m ap)	0.1-3 (1-8m ap.)	15-50	15-50	3-15	10-20	15-40	0.1-3 (1-8m ap.)	0.1-3 (1.5-10m ap.)		
4	3-15 (0.75-1.5m ap)	3-15 (0.5-1m ap)	50-90	>50	15-30	20-50	40-80	3-15 (0.5-1m ap.)	3-15 (0.75-1.5m ap.)		
5	15-90 (<0.75m ap)	15-50 (0.1-0.5m ap)	>90		>30	50-90		15-75 (0.01-0.5m ap)	15-50 (<0.75m ap.)		
6	>90	>50 (< 0.1m ap.)				>90		>75	50-90		
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Sombroek (1986); Van de Weg (1978); Spaargaren (1980) Tijmons (?); del Posso (1974)

2 Soil Conservation Service (1981); Day et al (1983); Maignien (1980)

3 Staring (1982)

4 Andriesse et al (1985)

5 Shields (1985)

6 Mc Donald et al (1984)

7 FAO (?)

8 Soil Conservation Service (1983)

9 SNLCS (1979)

10

E2.2 Surface stoniness-size (cm).

Reference Classes	1 rounded	2 flat	3	4	5	6	7	8	9	10	Proposal
1	0.2-0.5	0.2-15	0.2-0.6	< 0.2	0.2-7.5						
2	0.5-2	15-38	0.6-2	0.2-2	7.5-25						
3	2-7.6	38-60	2-6	2-20	>25						
4	7.6-25	>60	6-20	>20							
5	25-60		20-60								
6	>60		60-200								
7			>200								
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1981)

2 Soil Conservation Service (1981)

3 McDonald et al (1984)

4 Maignien (1980)

5 FAO (1977)

6

7

8

9

10

E2.3 Surface Stoniness-shape.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	angular	angular									
2	subangular	rounded									
3	subrounded	flat									
4	rounded										
5	angular-tabular										
6	subangular-tabular										
7	subrounded-tabular										
8	rounded-tabular										
9	angular-platy										
10	subangular-platy										
11	subrounded-platy										
12	rounded-platy										

References:

1 Mc Donald et al (1984)

2 FAO (1977)

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E3 Rock outcrops - abundance (%).

Definition: rock outcrops refer to any exposed area of rock that is inferred to be continuous with underlying bedrock (McDonald et al, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-2 (>100m apart)	0-2	0-2	0	0	0-2	< 2				
2	2-10 (35-100m ap.)	2-15	2-10	<10	<10	2-5/2-10	2-10 (30-100m ap.)				
3	10-25 (10-35m ap.)	15-50	10-25	10-15	10-50	10-50	10-25 (10-30m ap.)				
4	25-50 (3.5-10m ap.)	50-90	25-50	>50	50-90	50-90	25-50 (3-10m ap.)				
5	50-90 (<3.5m ap.)	>90	50-90		>90	>90	50-90 (< 3m ap.)				
6	>90						>90				
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Sombroek (1986); Van de Weg (1978); Day (1983); Tijmons (?) Maignien (1980); Segalen (1984); Spaargaren (1980); del Posso (1974)

2 Staring (1982)

3 Andriesse et al (1985)

4 Mc Donald et al (1984)

5 Hodgson (1976)

6 Maignien (1969)

7 SNLCS (19..)

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E4.1 Surface sealing/crusting - degree.

Definition: surface sealing is the packing of dispersed particles in the surface layer of a soil, rendering it relatively impermeable to water (Visser, 1980).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	unslaked	nil									
2	partly slaked	partly slaked									
3	slaked	slaked									
4		capped									
5											
6											
7											
8											
9											
10											
11											
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References:

1 Hodgson (1976)

2 Soil Conservation Service (1979)

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B6.1 Water table-depth (cm).

Definition: water table refers to the upper surface of ground water or that level in the ground where the water is at atmospheric pressure (Soil Science Society of America, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	>120	absent	>150	0-200	>80	>200					
2	temporaly 60-120	always >200	100-150	200-300	40-80	160-200					
3	always 60-120	always >120	75-100	>300	25-40	130-160					
4	temporaly <60	temporaly 60-120	50-75	0-100	15-25	80-130					
5	always <60	always 60-120	<50	100-200	<15	40-80					
6		temporaly <60				20-40					
7		always <60				<20					
8											
9											
10											
11											
12											

References:

1 Sombroek (1986)

2 Van de Weg (1978)

3 Staring (1982)

4 Shields (1985)

5 Haans (1979)

6 Benzler et al (1982)

7

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B6.2 Water table-kind.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	none	perched	apparent								
2	flooded	artesian	perched								
3	perched	other	other								
4	apparent	unknown									
5	ground-water-table										
6											
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1979)

2 FAO (1986)

3 Day et al (1983)

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E7.1 Inundation frequency (times/year).

Definition: inundation is the temporary covering of the soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Shallow water standing or flowing during or shortly after rain, or snowmelt, both as water that forms a permanent covering is excluded from the definition (Soil Conservation Service, 1983).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0	0	1/≥10	1 year in 10	every 10 years						
2	0-5/100	<1/100	1/5-10	1 year in 5	every 6-10 years						
3	5-50/100	1/50-100	1/3-5	annual	every 3-5 years						
4	>50/100	1/10-50	1/1-3		every 1-2 years						
5	common	1/1-10	1/1		<1 year						
6		>1/1									
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1983)

2 Mc Donald et al. (1984)

3 Braun et al. (1977)

4 Shields (1985)

5 Spaargaren (1980)

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E7.2 Inundation-duration.

d = days y = years
m = months s = season

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0	0	<1 day	0	<3m/1y	<30 d					
2	1-2m/3-5y	<1m/1y or <2d/1s	1-20 d	2-5d/1y, 1y/2	3-9m/1y	30-90 d					
3	2-3m/2y	1-3m/1y or 2-5d/1s	20-120 d	5-10d/1y, 1y/2	>9m/1y	90-180 d					
4	2-4m/ 1y	3-6m/1y or 5-10d/1s	>120 d	10-20d/1y, 1y/2		180-335 d (40-70cm depth)					
5	>4m/1y	>6m/1y or >10d/1s		1-3m/1y, 1y/2		180-335 d					
6				>3m/1y every year		>335 d					
7											
8											
9											
10											
11											
12											

References:

1 Braun et al. (1977)

2 Staring (1982)

3 Mc Donald et al. (1984)

4 Mori et al. (1983)

5 Maignien (1980)

6 Jarvis et al. (1973)

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E7.3 Inundation depth (cm).

Definition: inundation depth is the maximum depth of water in an inundation event (McDonald et al, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<5										
2	5-10										
3	10-30										
4	30-100										
5	>100										
6											
7											
8											
9											
10											
11											
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References:

1 Mc Donald et al. (1984)

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E7.4 Inundation - water quality.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	saline	fresh	tasteless								
2	brakish	saline	sapid								
3	fresh	no data	slightly saline								
4	oxygenated		saline								
5	still or stagnant										
6											
7											
8											
9											
10											
11											
12											

<u>References</u>:

1 FAO (1986)

2 Young (1983)

3 Maignien (1980)

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ES **Surface runoff.** (external soil drainage) Definition: surface runoff refers to the relative rate at which water flows away from the soil over the surface without infiltrating. The water may come from precipitation or run-on from adjacent areas (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	ponded	very slow	no run-off								
2	very slow	slow	very slow								
3	slow	medium	slow								
4	medium	rapid	mod. rapid								
5	rapid	very rapid	rapid								
6	very rapid		very rapid								
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1981); Van de Weg (1978); Spaargaren (1980); Tijmons (?)
2 Sombroek (1986)
3 Mc Donald et al. (1984)
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E9.1 Internal drainage-permeability (cm/hr). Definition: permeability or saturated hydraulic conductivity is the rate of water movement within the soil (Soil Conservation Service, 1981). It is a measure of the ease with which water moves through the soil. If permeability is applied to a soil profile, the water transmitting potential of the least permeable layer within the soil series control section is implied.

Reference Classes	1*	2	3**	4	5	6	7	8	9*	10*	Proposal
1	<1	<0.5	<0.01	<0.1	<0.5	<0.015	unknown	<0.04	<5	<1	
2	1-400	0.5-2	0.01-0.1	0.1-0.5	0.5-15	0.015-0.15	<0.2	0.04-4.5	5-10	1-10	
3	>100	2-6	0.1-1	0.5-2	>15	0.15-0.5	0.2-0.5	4.5-45	10-20	10-25	
4		6-12	1-10	2-6		0.5-1.5	0.5-1.6	>45	20-40	25-50	
5		>12	10-100	6-12.5		1.5-5.0	1.6-5		40-80	50-100	
6			>100	12.5-25		5.0-15	5-16		80-160	>100	
7				>25		15-50	16-50		160-320		
8						>50	>50		>320		
9											
10											
11											
12											

1*, 9*, 10* expressed in cm/day
3** expressed in cm/sec

References:

1 Mc Donald et al (1984)

2 Staring (1982)

3 Soil Conservation Service (1981 & 1983)

4 Van de Weg (1978)

5 Shields (1985)

6 Day (1983)

7 Soil Conservation Service (1979)

8 Maignien (1980)

9 Ilaco (1981)

10 Spaargaren (1980)

E9.1 Internal drainage-permeability (cm/hr). (cont.)

Reference Classes	11	12	13*	14*	15	16*	17	18	19	20	Proposal
1	< 0.05	< 0.16	< 20	< 20	< 0.8	< 1					
2	0.05-0.15	0.16-0.50	20-140	20-50	0.8-2.0	1-10					
3	0.15-0.5	0.5-1.6	140-300	50-140	2.0-6.0	10-40					
4	0.5-1.5	1.6-5.0	> 300	140-190	6.0-8.0	40-100					
5	1.5-5	5-16		190-300	8.0-12.5	100-300					
6	5-15	16-50		> 300	> 12.5	> 300					
7	15-50	> 50									
8	> 50										
9											
10											
11											
12											

13*, 14*, 16* expressed in cm/day

References:

11 Mc Keague et al (1986)

12 USDA (1971)

13 Landon (1984)

14 FAO (1963)

15 FAO (1963)

16 Benzler et al (1982)

17

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E9.2 Internal drainage-drainage.

Definition: drainage refers to the rapidity and extent of water removal from the soil profile or site (McDonald et al, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	very poorly	very poorly	very poorly	very poorly	poorly & very poorly imperfectly	very poorly	very poorly	unknown	unknown	inundated	
2	poorly	poorly	poorly	poorly		poorly	poorly	poorly	very poorly	very poorly	
3	imperfectly	imperfectly	somewhat poorly	imperfectly	moderately well	imperfectly	imperfectly	imperfectly	poorly	poorly	
4	moderately well	moderately well	moderately well	moderately well	well	well	moderately well	well	somewhat poorly	imperfectly	
5	well	well to excessively	well	well	excessively & somew.exc.	rapidly	well		moderately well	moderately well	
6	somewhat excessively		somewhat excessively	rapidly		excessively	rapidly		well	well	
7	excessively		excessively				very rapidly		somewhat excessively	rapidly	
8									excessively	excessively	
9									altered-drained		
10									altered-wetted		
11											
12											

References:

1 FAO (1977); van de Weg (1978); Spaargaren (1980); del Posso (1974)

2 Braun et al (1977); Staring (1982)

3 Soil Conservation Service (1981); Tijmons (?)

4 Mc Donald (1984)

5 Andriesse et al (1985)

6 Anonymous (1985)

7 Day (1983)

8 Shields (1986)

9 Soil Conservation Service (1979)

10 Maignien (1980)

E9.2 Internal drainage-drainage. (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	very poorly	very poorly	very poorly								
2	poorly	poorly	poorly								
3	rather well	imperfectly	imperfectly								
4	well	well	moderately well								
5	very well	excessively	well								
6			very well								
7			strongly								
8			excessively								
9											
10											
11											
12											

References:

11 Segalen et al (1984)

12 Fitzpatrick (1983)

13 SLNCS (1979)

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E10 Moisture condition.

Definition: moisture condition describes the soil water state of a layer of soil (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	dry	very dry	dry	dry	dry	dry	dry				
2	moist	fairly dry	slightly moist	moderately dry	fresh	just moist	moderately moist				
3	wet	fairly moist	moist	moist	damp	moist	moist				
4		moist	very moist	wet	moist	wet	wet				
5		wet	wet		wet						
6		saturated									
7											
8											
9											
10											
11											
12											

References:

1 Spaargaren (1980); Ferrari et al (1965); Ministry of Agriculture and Forestry Japan (1955); Hodgson (1976); Soil Conservation Service (1981)

2 Jamagne (1967)

3 ORSTOM (1969); Kohl (19719; Szabolcs (1966)

4 All India Soil and Land Use Survey Organization (1971)

5 Kachinskii (1966)

6 Ballantyne (1962)

7 Mc Donald et al (1984)

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E11 Water retention difference (cm).

Definition: the amount of water that a soil can hold between 33 kPa and 1,500 kPa within the zone accessible to roots is the commonly used measure of water retention difference of the soil, which in the past has been referred to as the available water capacity (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4*	5	6 in %	7 in %	8 in %	9 in %	10	Proposal
1	< 7.5	< 5	< 4	< 8	< 10	5-10	< 7.5	< 5	< 5	< 10	
2	7.5-15	5-10	4-8	8-12	10-20	10-14	7.5-15	5-10	5-9.9	10-15	
3	15-22.5	10-15	8-12	12-16	20-30	14-20	15	10-15	10-14.9	15-20	
4	22.5-30	15-20	12-16	>16	>30		unknown	15-20	15-19.9	> 20	
5	>30	>20	16-20					>20	20-24.9		
6									≥ 25		
7											
8											
9											
10											
11											
12											

4* downgrade by one class for strongly stratified soils and by two classes for Solontetz and for Sodic phases.

References:

1 Soil Conservation Service (1981)

2 Staring (1982)

3 Braun et al (1977)

4 Andriesse et al (1985)

5 Schroeder (1984)

6 Segalen et al (1984)

7 Shields (1986)

8 Sombroek (1986)

9 Mc Keague et al (1986)

10 Hodgson (1976)

E11 Water retention difference (cm). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	< 2.5										
2	2.5-5										
3	5-7.5										
4	7.5-13										
5	> 13										
6											
7											
8											
9											
10											
11											
12											

References:

11 Griffiths (1975)

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E12 Actual water erosion.

Definition: water erosion results from disturbance of the soil surface by flowing water and the material it carries. A part of the process is the detachment of soil particles by the impact of raindrops (Soil Conservation Service, 1981).

Reference Classes	1	2	3*	4	5
1	< 25% surface soil eroded	<25% lost of A horizon or of upper 20 cm if A horizon was < 20 cm thick	at most shallow rills (>50m apart)	<10% of topsoil removed	no erosion
2	25-75% surface soil eroded	25-75% lost of A horizon or of upper 20 cm if A horizon was < 20 cm thick	sheet erosion, shallow rills (20-50m) apart	10-25% of topsoil removed	1/4 of topsoil washed away, occasional crossable gullies
3	>75% surface soil eroded	>75% lost of A horizon or of upper 20 cm if A horizon was < 20 cm thick	shallow rills (<20m apart), moderate deep gullies (20-50m apart)	25-50% of topsoil removed	3/4 of topsoil removed, crossable gullies present
4	severely gullied	lost all A horizon or upper 20 cm if A horizon was<20cm thick	very dense rills/mod. deep gullies (<20 m apart), deep gullies(20-50m apart)	50-75% of topsoil removed	part of subsoil removed
5			land destroyed by gully erosion	>75% of topsoil removed	3/4 of subsoil removed, much truncated by gullies
6					
7					
8					
9					
10					
11					
12					

3* shallow rill<10 cm deep; rill 10-25 cm deep; shallow gully 25-100 cm deep; deep gully >100 cm deep.

References:

1 Day (1983)

2 Soil Conservation Service (1981)

3 Sombroek (1986); Van de Weg (1978)

4 Taylor et al (1962)

5 Barrera (1961)

E12 Actual water erosion. (cont.)

Reference Classes	6	7	8	9	10
1	sheet erosion, shallow rills (20-50 m apart)	10% surface soil eroded	not apparently	no appreciable erosion	
2	shallow rills (<20m apart), mod. deep gullies (20-50m)	10-30% surface soil eroded	<25% lost of A horizon or of upper 20 cm if A horizon was < 20 cm thick	< 25% surface soil eroded	
3	very dense rills, mod. deep gullies (< 20 m apart)	30-60% surface soil eroded	25-75% lost of A horizon	25-75% surface soil eroded	
4	land destroyed by gully erosion	60-90% surface soil eroded	>75% lost of A horizon	>75% surface soil eroded	
5		90% surface soil eroded	A horizon completely removed and part of B horizon lost		
6			A and B horizon completely removed		
7					
8					
9					
10					
11					
12					

References:

6 Spaargaren (1980)

7 Benzler et al (1982)

8 SNLCS (1979)

9 Tijmons (?)

10

E13 Actual wind erosion.

Definition: wind erosion is the detachment, transportation and deposition of soil particles by wind (Soil Conservation Service, 1981)

Reference Classes	1	2	3	4	5
1	25-75% surface soil eroded	<25% lost of A horizon or of upper 20 cm if A horizon was <20 cm thick	0-1% of the area is affected	<10% of the area is affected	<10% of topsoil removed
2	>75% surface soil eroded	25-75% lost of A horizon or of upper 20 cm if A horizon was <20 cm thick	1-5% of the area is affected	part of A horizon removed/ few(10-40% of area) very shallow (5-15cm) hollows	10-25% of topsoil removed
3	profile destroyed	>75% lost of A horizon or of upper 20 cm if A horizon was <20 cm thick	part of A horizon removed/few (5-20% of area) very shallow (0-5cm) hollows	A horizon removed/common (40-75% of area) shallow (5-15 cm) hollows	25-50% of topsoil removed
4		lost all A horizon or upper 20 cm if A horizon was<20cm thick	A horizon removed/common (20-50% of area) shallow (5-15cm) hollows	many (>75% of area), moderate deep (>15 cm) hollows	50-75% of topsoil removed
5			many (>50% of area), mod. deep (>15 cm) hollows		>75% of topsoil removed
6					
7					
8					
9					
10					
11					
12					

References:

1 Day (1983)

2 Soil Conservation Service (1981)

3 Sombroek (1986)

4 Van de Weg (1978); Spaargaren (1980)

5 Taylor et al (1962)

6

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E13 Actual wind erosion. (cont.1)

Reference Classes	6	7	8	9	10
1	no wind erosion				
2	< 25 % surface soil eroded				
3	25-75 % surface soil eroded				
4	> 75 % surface soil eroded				
5	100 % surface soil eroded				
6					
7					
8					
9					
10					
11					
12					

References:

6 Tijmons (?)

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E14 Aggradation (area affected (%)).

Definition: aggradation refers to the presence of material deposited on a pre-existing soil surface as a result of wind and/or water erosion (McDonald et al, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-2	<10									
2	2-10	10-40									
3	10-40	40-75									
4	40-75	>75									
5	>75										
6											
7											
8											
9											
10											
11											
12											

References:

1 **Sombroek** (1986)

2 **Van de Weg** (1978)

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E16 Effective soil depth (cm).

Definition: the effective soil depth is the depth to which roots can easily penetrate throughout the year and where there is significant moisture storage (Van de Weg, 1978).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	≤10	≤25	≤25	≤50	≤25	≤20	≤5	≤20	≤25	variable	
2	10-25	25-50	25-50	50-100	25-50	20-30	5-15	20-50	25-50	40	
3	25-50	50-80	50-80	>100	50-80	30-40	15-40	50-80	50-100	40-80	
4	50-80	80-120	80-120		80-150	40-60	40-60	80-120	100-150	>80	
5	80-120	120-180	>120		>150	60-80	60-80	>120	>150		
6	>120	>180				>80	>80				
7	>180										
8											
9											
10											
11											
12											

References:

1 Van de Weg (1978)

2 Andriesse et al (1985)

3 Staring (1982)

4 Shields (1985)

5 Braun et al (1977)

6 Mori (1983)

7 INRA/CEE (?)

8 Sijs (?)

9 Soil Conservation Service (1981 & 1983); Sombroek (1986)

10 Maignien (1980)

E16 Effective soil depth (cm). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	<15	20-50	0-25	<25	<20	<20					
2	15-30	50-100	26-50	25-50	20-50	20-40					
3	30-60	100-150	51-100	50-90	50-90	40-80					
4	60-90	150-200	101-150	>90	>90	80-130					
5	90-120		unknown			>130					
6	>120										
7											
8											
9											
10											
11											
12											

References:

11 Ilaco (1981)

12 Day (1983)

13 Shields (1986)

14 Bartelli (1978)

15 Sheng (1972)

16 Benzler et al (1982)

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F2.1 Nature of boundary with horizon below - distinctness. (cm)

Definition: the distinctness of the nature of boundary with horizon below refers to the ease of determining the zone within which the boundary can be located at any level with equal confidence (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	2	2	0.5	0	0	2	1	0	2.5	3	
2	2-5	2-5	0.5-2	2	2	2-5	1-3	2.5	2.5-5	3-5	
3	5-15	5-12	2-5	2-5	2-4	5	3-5	2.5-7.5	5	5-10	
4	15	12	5-10	5-12	4-8		5	7.5		10	
5			10	12	8						
6											
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1981); Day (1983); Maignien (1969); Tijmons (?)

2 FAO (1977); Van de Weg (1978); FAO (1986); Sijs (1961); Spaargaren (1980); del Posso (1974)

3 Mc Donald et al (1984)

4 Maignien (1980); ORSTOM (1969)

5 Jamagne (1967)

6 Kohl (19719; Kachinskii (1966)

7 Ministry of Agriculture and Forestry Japan (1955)

8 Leamy et al (1966); Taylor et al (1962)

9 Jenkin (1963)

10 Barrera (1961)

P2.1 Nature of boundary with horizon below - distinctness (cm). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	2	0.5	2.5	2	2.5						
2	2-6	0.5-2.5	2.5-6.2	2-5	2.5-7.5						
3	6-12	2.5-6	6.2-12.5	5-10	7.5-12.5						
4	12	6-13	12.5	10-20	12.5						
5		13		20							
6											
7											
8											
9											
10											
11											
12											

References:

11 Carvalho Cardoso (1972)

12 Hodgson (1976)

13 Bown (1973)

14 Fitzpatrick (1983)

15 SNLCS (1979)

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F2.2 Nature of boundary with horison below —topography.

Definition: the topography of the nature of boundary with horizon below refers to irregularities of the boundary surface that divides the horizons (Tijmons, ?).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	smooth	smooth	smooth	smooth	smooth	even	sharp	smooth	smooth	smooth	
2	wavy	wavy	undulating	undulating	wavy	wavy	distinct	wavy	wavy	wavy	
3	irregular	irregular	irregular	strongly undulated	toothed	tongue shaped	gradual	irregular	lobate		
4	broken	gammate	broken	irregular	dendritic	broken	indistinct		irregular		
5		tongued		broken	lobed				tongued		
6		broken			angular						
7					broken						
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1981); FAO (1977)? Van de Weg (1978), Day (1983); Soil Conservation Service (1979); FAO (1986); Hodgson (1976); Spaargaren (1980); del Posso (1974)

2 Mc Donald et al (1984)

3 Maignien (1980); ORSTOM (1969); SNLCS (1979)

4 Jamagne (1967)

5 Godron et al (1968)

6 Kohl (1971)

7 Szabolcs (1966)

8 Ministry of Agriculture and Forestry Japan (1955)

9 Fitzpatrick (1983)

10 Tijmons (?)

F3.1 Color-hue.

Definition: hue identifies the quality of color registered by the eye as related to the wavelength of the light that reaches the eye (Soil Conservation Service, 1981)

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	10 R	5 Y	R								
2	2.5 YR	2.5 Y	YR								
3	5 YR	10 YR	Y								
4	7.5 YR	7.5 YR	GY								
5	10 YR	5 YR	G								
6	2.5 Y	2.5 YR	BG								
7	5 Y	10 R	B								
8	green	7.5 R	PB								
9	blue	neutral	P								
10	neutral		RP								
11											
12											

References:

1 Maignien (1980)

2 FAO (1986)

3 Soil Conservation Service (1979 & 1981)

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F3.2 Color-value.

Definition: the relative lightness or intensity of color is approximately a function of the square root of the total amount of light (Soil Science Society of America, 1984)

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0										
2	1										
3	2										
4	3										
5	4										
6	5										
7	6										
8	7										
9	8										
10	9										
11	10										
12											

References:

1 Munsell Color Company (1954)

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F3.3 Color-chroma.

Definition: chroma is the relative purity, strength, or saturation of a color; directly related to the dominance of the determining wavelength of the light and inversely related to grayness (Soil Science Society of America, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-3	0									
2	4-5	1									
3	6-10	2									
4		3									
5		4									
6		5									
7		6									
8		7									
9		8									
10											
11											
12											

References:

1 Maignien (1980)

2 Munsell Color Company (1954)

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F4.1 Mottles-abundance (% exposed surface).

Definition: mottles are spots, blotches or streaks of subdominant colours different from the the matrix colour and also different from the colour of the ped surface, nodules or concretions (McDonald et al, 1984). Mottles-abundance refers to the percentage of the observed surface that is occupied by mottles of a given kind (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<2	0	0	<2	1-2	<2	<5	<2	<2	<1	
2	2-20	<2	<2	2-20	2-5	2-15	5-20	2-20	3-10	1-2	
3	<20	2-10	2-20	20-50	5-15	15-30	>20	20-40	15-30(?)	2-5	
4		10-20	20-50	>50	15-30	30-50		>40	>30	5-10	
5		20-50			30-50					10-30	
6					>50					>30	
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); Day (1983); Soil Conservation Service (1981); Maignien (1969); Spaargaren (1980); SNLCS (1979); Tijmons (?); del Posso (1974)

2 Mc Donald et al (1984)

3 FAO (1986)

4 ORSTOM (1969); Maignien (1980)

5 Jamagne (1967)

6 Informatique et Biosphère (1971)

7 Kohl (1971)

8 Hodgson (1976)

9 Sijs (1961)

10 Benzler et al (1982)

F4.2 Mottles-size (mm).

Definition: the size of mottles refers to the approximate dimensions as seen on a plane surface (Soil Conservation Service, 1981). If the length of a mottle is not more than 2 or 3 times the width, the dimension recorded is the greater one. If the width is long and narrow, the width is described.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<5	<5	<5	<5	<5	<2	<1				
2	5-15	5-15	5-15	5-15	5-15	2-5	1-2				
3	>15		15-30	>15	>15	5-20	2-5				
4			>30	heterogeneous	0-15	20-50	5-15				
5					5-15	>50	>15				
6					0->15						
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); Maignien (1980); Soil Conservation Service (1981), Maignien (1969); Jenkin (1963); Spaargaren (1980); SNLCS (1979); Tijmons (?); del Posso (1974)

2 Day (1983)

3 Mc Donald et al (1984)

4 FAO (1968)

5 ORSTOM (1969)

6 Kohl (1971)

7 Hodgson (1976)

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F4.3 Mottles-contrast between mottles. Definition: contrast between mottles refers to the degree of visual distinction that is evident between associated colors (Day, 1983).

Reference Classes	1	2	3	4*	5
1	faint: close related hues and chromas	faint: indistinct, evident only on close examination	non-contrasting: hue and chroma are comparable	faint: 0; ≤ 2; ≤ 1 or 2.5; 0; 0	non-contrasting: hue and chroma are comparable; value can vary
2	distinct: difference in hue: 1-2, or difference in value or chroma: several units	distinct: readily evident although not striking	contrasting: difference in hue: ≤ 5; difference in value or chroma: < 3	distinct: 0;3-4;2-4 or 2.5; ≤ 2; ≤ 1	contrasting: difference in hue: < 2,5 and/or difference in value and chroma: 1-3
3	prominent: hue, chroma and value several units apart	prominent: striking and conspicious		prominent: ≥ 5; 0; 0 or 0; ≥ 4; ≥ 4; or 2.5; ≥ 2; ≥ 1	very contrasting: difference in hue: ≤ 5 and/or difference in value and chroma: 3
4					
5					
6					
7					
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4* difference from the matrix in hue, value and chroma respectively.

References:

1 FAO (1977); SNLCS (1979); del Posso (1974)

2 Van de Weg (1978); Mc Donald et al (1984); FAO (1986); Soil Conservation Service (1979); Spaargaren (1980)

3 ORSTOM (1969)

4 Day (1983); Soil Conservation Serice (1981); Tijmons (?)

5 Maignien (1980); Canada Department of Agriculture (1970)

F4.4 Mottles-sharpness of mottle boundaries.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	knife-edge	sharp	< 2 mm	very clear	< 1 mm						
2	transition < 2 mm	clear	> 2 mm	clear	1-2 mm						
3	transition > 2 mm	diffuse		unclear	> 2 mm						
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); ORSTOM (1969); Maignien (1980); Soil Conservation Service (1981); Hodgson (1976); Tijmons (?); del Posso (1974)

2 FAO (1986); Spaargaren (1980)

3 Maignien (1969)

4 Informatique et Biosphère (1971)

5 Fitzpatrick (1983)

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F5.1 Particle size - grade (mm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 0.002	< 0.002	< 0.0002	< 0.0002	< 0.0002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	
2	0.002-0.05	0.002-0.02	< 0.002	0.0002-0.0006	0.0002-0.00063	0.002-0.05	0.002-0.02	0.002-0.02	0.002-0.05	0.002-0.006	
3	0.05-0.1	0.02-0.2	0.002-0.005	0.0006-0.002	0.00063-0.002	0.05-0.2	0.02-0.05	0.02-0.05	0.05-0.105	0.006-0.02	
4	0.1-0.25	0.2-2.0	0.005-0.1	0.002-0.006	0.002-0.0063	0.2-0.5	0.05-0.1	0.05-0.2	0.105-0.15	0.02-0.06	
5	0.25-0.5		0.1-0.25	0.006-0.02	0.0063-0.02	0.5-2.0	0.1-0.25	0.2-2	0.15-0.21	0.06-0.2	
6	0.5-1.0		0.25-0.5	0.02-0.06	0.02-0.063		0.25-0.5	> 2.0	0.21-0.42	0.2-0.6	
7	1.0-2.0		0.5-1.0	0.06-0.2	0.063-0.2		0.5-1.0		0.42-2.0	0.6-2.0	
8			1.0-2.0	0.2-0.6	0.2-0.63		1.0-2.0				
9				0.6-2.0	0.63-2.0						
10											
11											
12											

References:

1 Soil Conservation Service (1981); USDA (1976)

2 Ilaco (1981); Carvalho Cardoso (1972)

3 Day (1983); Tijmons (?)

4 Schroeder (1984)

5 Kohl (1971); Benzler (1984)

6 Maignien (1980)

7 Soil Conservation Service (1972)

8 Jamagne (1967)

9 De Bakker et al (1966)

10 Hodgson (1976)

F5.1 Particle size - grade (mm). (cont.)

Reference Classes	11*	12	13	14	15	16	17	18	19	20	Proposal
1	< 0.001	< 0.02	< 0.002								
2	0.001-0.005	0.02-0.25	0.002-0.05								
3	0.005-0.01	0.25-2	0.05-0.2								
4	0.01-0.05		0.2-2								
5	0.05-0.25										
6	0.25-1.0										
7	1.0-3.0										
8	> 3.0										
9											
10											
11											
12											

11* upper size limit of mineral particles is 3 mm.

References:

11 Kachinskii (1943)

12 Sijs (1961)

13 SNLCS (1979)

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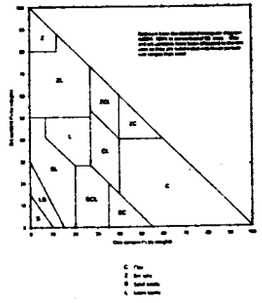
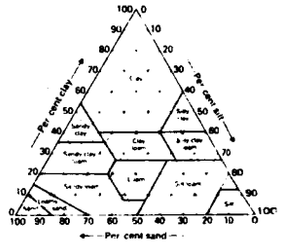
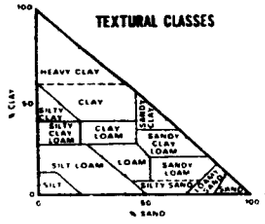
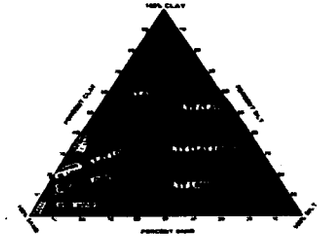
F5.3 Particle size - class.

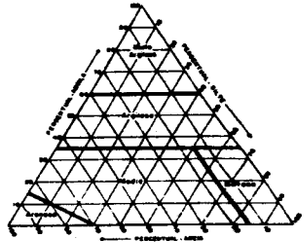
Reference	1	2	3	4	5











References:

1 USDA (1951)

2 FAO (1977); del Posso (1974)

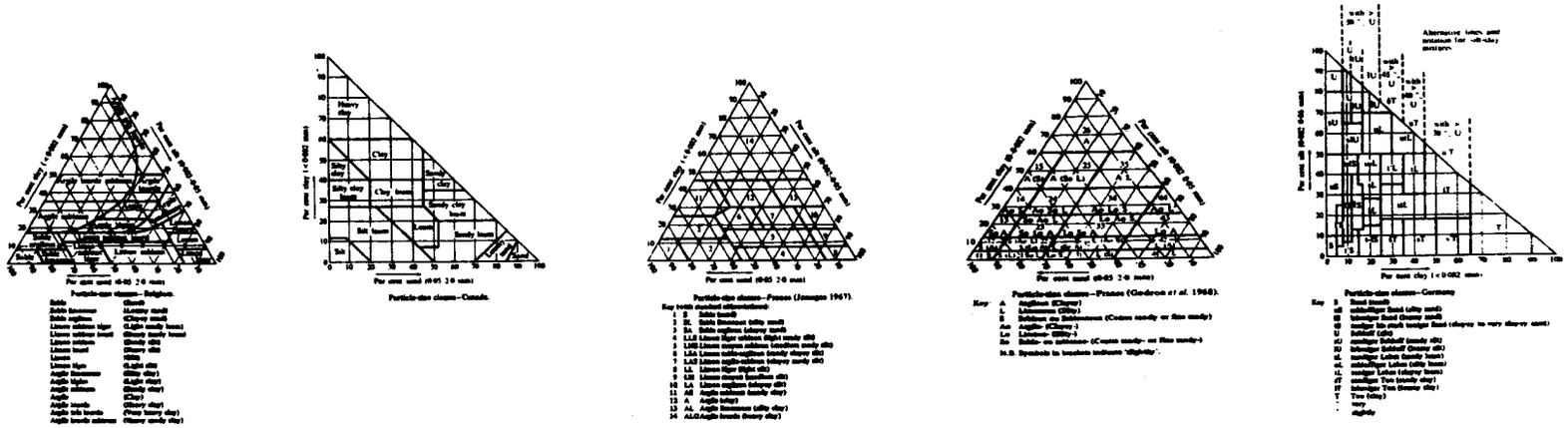
3 Day (1983)

4 McDonald et al (1984)

5 SNLCS (1979)

F5.3 Particle size - class. (cont.)

Reference	6	7	8	9	10



References:

6 Tavernier et al (1958)

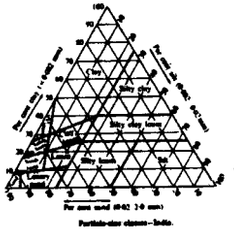
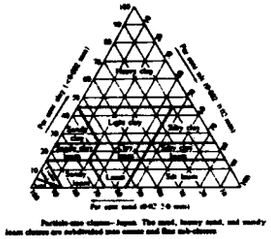
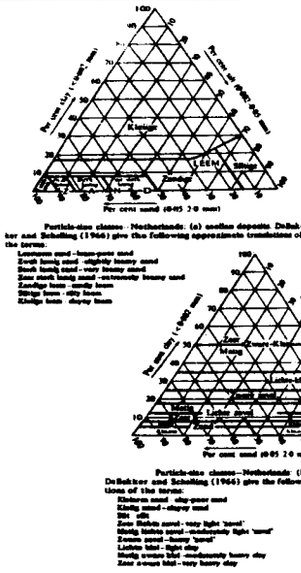
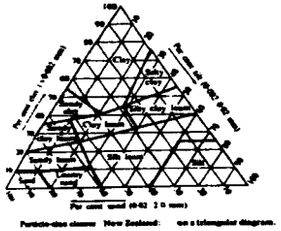
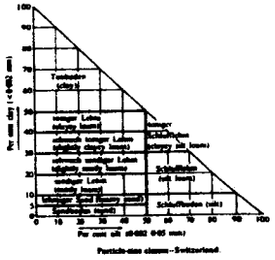
7 Canada Department of Agriculture (1970)

8 Jamagne (1967)

9 Godron et al (1968)

1o Kohl (1971)

F5.3 Particle size - class. (cont.)

Reference	11	12	13	14	15
					

References:

11 All India Soil and Land Use Survey Organization (1971)

12 Ministry of Agriculture and Forestry Japan (1955)

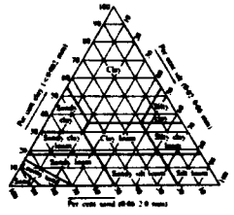
13 de Bakker et al (1966)

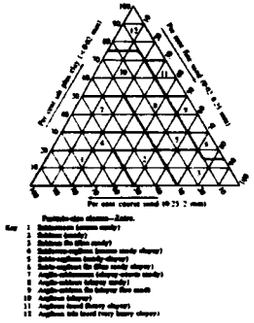
14 Taylor et al (1962)

15 Jäggli et al (1977)

F5.3 Particle size - class. (cont.)

Reference	16	17	18	19	20





References:

16 Hodgson (1976)

17 Sija (1961)

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F6.1 Stoniness in the profile-abundance (% volume). Definition: stoniness in the profile refers to particles larger than 2 mm diameter within the soil (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9*	10	Proposal
1	<15	2-15	0-2	<1	1-10	<5	<2	0-5	10-20 0-10	<5	
2	15-35	15-50	2-15	1-5	10-30	5-15	2-15	5-15	20-30 10-20	5-15	
3	35-60	50-90	15-50	6-15	30-75	15-50	15-30	15-30	30-50 20-30	15-25	
4	>60	>90	50-90	16-35	>75	50-80	30-50	30-50	50-75 30-50	>25	
5			>90	36-70		>80	>50	>50	>75 >50		
6				>70							
7											
8											
9											
10											
11											
12											

9* calcareous stones, siliceous stones respectively.

References:

1 Soil Conservation Service (1981); Day (1983)

2 FAO (1977); Van de Weg (1978); Maignien (1969)

3 Sombroek (1986); Staring (1982)

4 Hodgson (1976)

5 Schroeder (1984)

6 FAO (1986)

7 Maignien (1980)

8 INRA/CEE (?)

9 Mori et al (1983)

10 Jamagne (1967)

F6.1 Stoniness in the profile-abundance (% volume). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	0	< 2	< 5	<10	<7	<10	15-50	1	<15	<5	
2	3	2-5	5-10	10-30	7-30	10-50	50-90	1-5	15-50	5-25	
3	3-7	5-10	10-30	>30	>30	>50	15-90	6-15	>50	>25	
4	7-20	10-25	30-50					16-20			
5	20-50	25-50	>50					>20			
6	50-90	50-90									
7	90-100										
8											
9											
10											
11											
12											

References:

11 Godron et al (1968)

12 Ferrari et al (1965)

13 Ministry of Agriculture and Forestry Japan (1955)

14 Leamy et al (1966)

15 Taylor et al (1962)

16 Jenkin (1963)

17 Barrera (1961)

18 Jäggli et al (1977)

19 Bown (1973)

20 Laing (1976)

F6.1 Stoniness in the profile-abundance (% volume). (cont.)

Reference Classes	21*	22	23	24	25	26	27	28	29	30	Proposal
1	>0.5	>5	0	>2	>1	0					
2	0.5-5	5-15	0-20	2-10	1-10	0.01-0.1					
3	5-10	15-40	20-40	10-20	10-30	0.1-3					
4	< 10	40-80	40-60	20-50	30-50	3-15					
5		< 80	< 60	50-90	50-75	15-50					
6				< 90	< 75	50-90					
7											
8											
9											
10											
11											
12											

21*: % fragment > 0.3 cm.

References:

21 Kachinskii (1966)

22 Spaargaren (1980); del Posso (1974)

23 Griffiths (1975)

24 Mc Donald et al (1984)

25 Benzler et al (1982)

26 SNLCS (1979)

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F6.2 Stoniness in the profile-size (cm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0.2-7.5	0.2-7.5	0.2-0.63	0.2-0.6	0.2-2	0.2-1.9	0.2-2	0.2-7.5	0.2-2	0.2-5	
2	7.5-25	7.5-20	0.63-2	0.6-2	2-7.5	1.9-8	2-7.5	7.5-20	2-20	5-10	
3	>25	20-60	2-6.3	2-6	7.5-12	8-25	7.5-20	>20	>20	10-25	
4		>60	6.3-20	6-20	12-25	25-60	>25			>25	
5			>20	20-60	>25	>60					
6				>60							
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978)

2 Schroeder (1984)

3 Kohl (1971); Benzler et al (1982)

4 Hodgson (1976)

5 FAO (1986)

6 Soil Conservation Service (1979)

7 Maignien (1980)

8 Maignien (1969)

9 ORSTOM (1969); Informatique et Biosphère (1971); SNLCS (1979)

10 Ferrari et al (1965)

F6.2 Stoniness in the profile-size (cm). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20 inches	Proposal
1	0.2-2	<1	<0.6	<1	0.2-4	0.21-2	0.2-0.5	<2.5	<0.2	0.125-0.25	
2	2-5	1-20	0.6-1.2	1-5	4-8	2.1-5	0.5-2	2.5-7.5	0.2-1	0.25-0.5	
3	5-10	>20	1.2-1.9	>5	8-25	5.1-25	2-5	>7.5	>1	0.5-1	
4	10-20		1.9-5		25-60	25.1-50	5-10			1-2	
5	>20		5-10		>60	>50	10-20			2-4	
6			10-20				>20			4-8	
7			>20							>8	
8											
9											
10											
11											
12											

References:

11 Ministry of Agriculture and Forestry Japan (1955)

12 Leamy et al (1966)

13 Taylor et al (1962)

14 Jenkin (1963)

15 Barrera (1961)

16 Jäggli et al (1977)

17 Carvalho Cardoso (1972)

18 Ballantyne (1962)

19 Spaargaren (1980)

20 Clarke et al (1971)

F6.2 Stoniness in the profile-size (cm). (cont.)

Reference Classes	21	22	23	24	25	26	27	28	29	30	Proposal
1	0.2-0.6	0.2-1	0.2-0.5	0.2-0.5	0.2-1						
2	0.6-2	1-5	0.5-1	0.5-2	1-5						
3	2-6	5-10	1-5	2-7.5	5-7.5						
4	6-20	>10	5-10	7.5-25	7.5-25						
5	20-60		>10	25-60	>25						
6	60-200			>60							
7	>200										
8											
9											
10											
11											
12											

References:

21 Mc Donald et al (1984)

22 Fitzpatrick (1983)

23 Fitzpatrick (1980)

24 Tijmons (?)

25 del Posso (1974)

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F6.3 Stoniness in the profile-degree of weathering.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	fresh	unweathered	fresh								
2	partly	partly	weathered								
3	(strongly) weathered	weathered	strongly weathered								
4	mixed	strongly									
5		unidentified									
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1986)

2 Maignien (1980)

3 Spaargaren (1980); del Posso (1974)

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F7.1 Structure-grade.

Definition: soil structure refers to the natural organization of soil particles into units. These units are separated by surfaces of weakness. The surfaces persist through more than one cycle of wetting and drying in place (Soil Conservation Service, 1981). The grade of structure is the degree of aggregation and expresses the differntial between cohesion within aggregates and adhesion between aggregates (USDA, 1951).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	structure-less	weak	structure-less	structure-less	very weak	structure-less	indistinct	apedal			
2	weak	moderate	very weak	very weak	weak	weak	distinct	weak			
3	moderate	strong	weak	weak	moderate	very weak adherent	very distinct	moderate			
4	strong		moderate	weak to moderate	strong	weak		strong			
5			strong	moderate		weak to moderate		compound			
6				moderate to strong		moderate					
7				strong		moderate to strong					
8						strong					
9						very strong					
10											
11											
12											

References:

1 FAO(1977); Van de Weg(1978); Schroeder(1984); Mc Donald et al(1984); Godron (1968); Maignien(1969); Ilaco(1981); Carvalho Cardoso(1972); Tijmons(?); del Posso (1974)

2 Soil Conservation Service (1981); Ballantine (1962); Spaargaren (1980)

3 Staring (1982)

4 Day (1983); Mc Keague et al (1986)

5 FAO (1986)

6 Soil Conservation Service (1979)

7 Maignien (1980); ORSTOM (1969)

8 Hodgson (1976)

9

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F7.2 Structure-type.

Definition: structure type refers to a classification based on the shape of peds and their arrangement in the soil profile (Visser, 1980).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	platy	platy	columnar, massive	platy	platy	platy	platy	cubic	columnar	platy	
2	prismatic	prismatic	prismatic, massive	prismatic	prismatic	lenticular	prismatic	prismatic	prismatic	prismatic	
3	columnar	columnar	angular blocky, platy	columnar	columnar	prismatic	polyhedral	platy	subangular	polyhedral	
4	angular blocky	angular blocky	subangular blocky	angular blocky	angular blocky	columnar	granular	lamellate	angular blocky	crumb	
5	subangular blocky	subangular blocky	granular, crumb	subangular blocky	subangular blocky	blocky	crumb	tetrahedral	oblique platy		
6	granular	granular		granular	granular	angular blocky		scaly	cubic		
7	crumb			massive	crumb	subangular blocky		columnar	scaly		
8				single grain	massive	granular		angular blocky	platy		
9					single grain	crumb		crumb	crumb		
10					wedge shaped	massive		subangular blocky	granular		
11						single grain		granular			
12						wedge cloddy					

References:

1 FAO (1977); Van de Weg (1978); Schroeder (1984); Ilaco (1984); Spaargaren (1980); Tijmons (?); del Posso (1974)

2 Soil Conservation Service (1981)

3 Staring (1982)

4 Day (1983)

5 FAO (1986)

6 Soil Conservation Service (1979)

7 Jamagne (1967)

8 Maignien (1969)

9 ORSTOM (1969)

10 Kohl (1971)

F7.2 Structure-type. (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	massive	platy	lenticular	platy							
2	single grained	prismatic	flaky	lenticular platy							
3	platy	blocky	platy	prismatic							
4	prismatic	angular	prismatic	columnar							
5	cubiclike	crumb	columnar	angular blocky							
6	cubic		granular	subangular blocky							
7	nutty		nuciform	granular							
8	cloddy		crumby								
9	granular		cloddy								
10	crumb										
11											
12											

References:

11 Ministry of Agriculture and Forestry (1955)

12 Jenkin (1963)

13 Tijurin et al (1965)

14 Benzler et al (1982)

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F7.3 Structure-size.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	very fine	very fine	<2 mm	ultrafine	small	fine	<2 mm	extremely fine			
2	fine	very fine to fine	2-5 mm	very fine	medium	medium	2-5 mm	very fine			
3	medium	fine	5-10 mm	very fine to fine	large	coarse	5-20 mm	fine			
4	coarse	fine to medium	10-20 mm	fine		very coarse	20-50 mm	medium			
5	very coarse	medium	20-50 mm	fine to medium			50-100 mm	coarse			
6		medium to coarse	50-100 mm	medium			100-200 mm	very coarse			
7		coarse	100-200 mm	medium to coarse			>200 mm				
8		very coarse	200-500 mm	coarse							
9			>500 mm	very coarse							
10											
11											
12											

References:

1 FAO (1977); Soil Conservation Service (1981); Van de Weg (1978); Schroeder (1984); FAO (1986); Maignien (1980); Jamagne (1967); ORSTOM (1969); Kohl (1971); Ilaco (1981); Spaargaren (1980); del Posso (1974)

2 Day (1983)

3 Mc Donald et al (1984)

4 Soil Conservation Service (1979)

5 Jenkin (1963)

6 Mc Keague et al (1986)

7 Benzler et al (1982)

8 Tijmons (?)

9

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F8.1 Surface features-abundance (% exposed surface). Definition: surface features include (1) coats of a variety of substances unlike the adjacent soil material and covering part or all of surfaces (2) materials concentrated on surfaces by the removal of other material and (3) stress formations in which thin layers at the surfaces have undergone reorientation or packing. The abundance of surface features refers to the area occupied by a particular surface feature over the extent of the horizon (Soil Conservation Service, 1981)

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0	5	2	20	0	10					
2	10	5-25	2-20	20-50	20	10-50					
3	10-50	25-50	20-80	50-80	20-80	50					
4	50	50	80	80	80						
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1979); Mc Donald et al (1984)

2 Soil Conservation Service (1981); Tijmons (?)

3 Day (1983)

4 ORSTOM (1969)

5 Maignien (1980)

6 Hodgson (1976)

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FS.2 Surface features-thickness (mm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	thin	0.5	0.005	thin	0.05						
2	moderately thick	0.5-1.0	0.005-0.05	thick	0.05-0.5						
3	thick	1.0	0.05-0.5	very thick	0.5						
4			0.5-1.0								
5			1.0								
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); FAO (1986); Tijmons (?); Spaargaren (1980); del Posso (1974)

2 Soil Conservation Service (1979)

3 Day (1983)

4 ORSTOM (1969)

5 Maignien (1980)

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F8.3 Surface features-continuity.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	patchy	patchy	none	patchy							
2	broken	discontinuous	patchy	discontinuous							
3	continuous	continuous	broken	continuous							
4			continous	entire							
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); del Posso (1974)

2 Soil Conservation Service (1979)

3 FAO (1986)

4 Hodgson (1976)

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F8.4 Surface features-distinctness.

Definition: the distinctness of surface features refers to the ease and degree of certainty with which a surface feature can be identified (Soil Conservation Service, 1981)

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	unknown	faint									
2	faint	distinct									
3	distinct	prominent									
4	prominent										
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1979)

2 Soil Conservation Service (1981); Mc Donald et al (1984); Hodgson (1976); Tijmons (?)

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F8.5 Surface features-type.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	cutans	clay skins	no cutans	clay skins	unknown	unknown	clay	clay+iron oxides/hydr.	clay	clay skins	
2	pressure faces	claybridges	unspecified	slicken-sides	chalcedony	organic	sand or silt	clay + humus	sesquioxide	sesquioxide	
3	slicken-sides	sand or silt coats	clay skins	metallic oxides	gibbsite	clay	sesqui-oxidic	sesqui-oxides	silt	silt	
4		other coats	other cutans	pressure faces	lime or carbonates	clay film + iron oxides	organic	humus	calcite	calcite	
5		stress surfaces		humus coatings	manganese or iron mang.	clay film + org.matter	carbonate	manganese (hydr)oxides	silica	silica	
6		slicken-sides			clay films	sesqui-oxidic	stress	soluble salts	manganese dioxide	manganese dioxide	
7					clay films + iron oxides	manganese		silica	organic	organic	
8					clay films + org.matter	soluble salts		slicken-sides	whole soil	whole soil	
9					organic	silicuous			ice	faecal material	
10					soluble salts	silty			composite	ice	
11						sandy			compound	composite	
12						complex				compound	

References:

1 FAO (1977)

2 Soil Conservation Service (1981)

3 Mc Donald et al (1984)

4 Van de Weg (1978)

5 FAO (1986)

6 Maignien (1980)

7 Hodgson (1976)

8 Spaargaren (1980)

9 Fitzpatrick (1983)

10 Fitzpatrick (1980)

FS.5 Surface features-type. (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	clay skins										
2	clay-iron skins										
3	clay-humus skins										
4	clay bridges										
5	sand bridges										
6	silt coats										
7	carbonate coats										
8	manganese coats										
9	gibbsite coats										
10	stress surfaces										
11	slicken-sides										
12											

References:

11 Tijmons (?)

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F8.6 Surface features-location. Definition: the location of surface features refers to the kind of surface on which coats are observed (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5
1	on ped faces (horizontal or vertical or both)	in voids and/or channels only	in root channels or pores only	in voids and/or channels	in voids and/or channels
2	on upper surfaces of peds or stones	on ped faces	on ped faces, general	on ped faces, general	on grains
3	on lower surfaces of peds or stones	in many voids/channels and on some ped faces	on horizontal ped faces	on horizontal ped faces	on ped faces, general
4	on tops of columns	in all voids/channels and all ped faces	on vertical ped faces	on vertical ped faces	
5	on bottom of plates	visible bridges between sand grains	bridges between sand grains	on grains	
6	on sand and gravel		on sand and gravels		
7	bridges between sand grains				
8	in root channels and/or pores				
9	throughout soils				
10	on nodules				
11					
12					

References:

1 Soil Conservation Service (1979)

2 Day (1983)

3 FAO (1986)

4 ORSTOM (1969)

5 Maignien (1980)

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F8.6 Surface features-location. (cont.)

Reference Classes	6	7	8	9	10
1	some ped surfaces	on ped surfaces			
2	all ped surfaces	on horizontal pedfaces			
3	channels	on vertical pedfaces			
4	pores	both horizontal & vertical pedfaces			
5	primary particles or grains	on top of columns			
6	soil fragments	on sand and gravel			
7	rock fragments	bridges between sand grains			
8	nodules	in root channels and/or pores only			
9	concretions	on nodules			
10					
11					
12					

References:

6 Soil Conservation Service (1981)

7 Tijmons (?)

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F9.1 Porosity-abundance.

Definition: porosity is the proportion of the soil volume unoccupied by soil particles. In soil descriptions, useful estimates can be made of the total porosity (from estimated bulk density) and of the volume of pores that drain at low negative pressures (air porosity).

Reference Classes	1 dm^2	2 % volume	3* dm^2	4 dm^2	5 % volume	6 dm^2	7 dm^2(?)	8 % volume	9** % volume	10	Proposal
1	1-50	40	100	15	absent	1	10	2	5		
		b.d. 1.6	1								
2	51-200	40-60	100-500	15-75	20	1-50	10-25	2-20	5-9.9		
		b.d. 1.1-1.6	1-5								
3	200	60	500	75-200	20-40	51-200	25-20	20	10-14.9		
		b.d. 1.1	5								
4				200	40	200	50		15-20		
5									20		
6											
7											
8											
9											
10											
11											
12											

3* pores < 2 mm diameter and > 2 mm diameter respectively
9** pores > 0.06 mm diameter

References:

1 FAO (1977); Van de Weg (1978); FAO (1986); Taylor et al (1962); Spaargaren (1980)

2 Day (1983); Tijmons (?)

3 Mc Donald et al (1984); Soil Conservation Service (1981)

4 ORSTOM (1969); Maignien (1980)

5 Maignien (1980)

6 Canada Department of Agriculture (1970); ORSTOM (1969)

7 Maignien (1980)

8 All India Soil and Land Use Survey Organiz. tion (1971); Tijmons (?)

9 Hodgson (1976); Mc Keague et al (1986)

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F9.2 Porosity-size (mm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0.075	0.1	0.2	0.075-1	1	0.5	1	0.5	1	0.1-0.5	
2	0.075-1	0.1-0.5	0.2	1-2	1-2	0.5-2	1-2	0.5-2	1-3	0.5-2	
3	1-2	0.5-2		2-5	2-5	2-5	2-5	2-10	3-5	2-5	
4	2-5	2-5		5	5	5	5-10	10	5-10	5	
5	5	5-10					10		10		
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Mc Donald et al (1984); Soil Conservation Service (1979); Canada Department of Agriculture (1970); del Posso (1974)

2 Day (1983)

3 Van de Weg (1978)

4 FAO (1986)

5 ORSTOM (1969); Maignien (1980)

6 Soil Conservation Service (1981); Hodgson (1976); Tijmons (?)

7 All India Soil & Land Use Survey Organization (1971); SNLCS (1979)

8 Ministry of Agriculture and Forestry Japan (1955)

9 Kachinski (1966)

10 USDA (1976)

F9.2 Porosity-size (mm). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	0.075	2									
2	0.075-1	2-5									
3	1-2	5-20									
4	2-5	20									
5	5-10										
6	10										
7											
8											
9											
10											
11											
12											

References:

11 Spaargaren (1980)

12 Tijmons (?)

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F9.3 Porosity-continuity.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	continuous	continuous	unspecified								
2	discon-tinuous	constricted	continuous								
3		discon-tinuous	discon-tinuous								
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Day (1983); Canada Department of Agriculture (1970); Spaargaren (1980); del Posso (1974)

2 USDA (1976)

3 Tijmons (?)

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F9.4 Porosity-orientation.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	vertical	unspecified									
2	horizontal	vertical									
3	oblique	horizontal									
4	random	oblique									
5		random									
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Day (1983); Maignien (1980); Canada Department of Agriculture (1970); USDA (1976); del Posso (1974)
2 Tijmons (?)
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F9.5 Porosity-distribution.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	inped	unspecified									
2	exped	inped									
3		exped									
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Day (1983); Soil Conservation Service (1981); Canada Department of Agriculture (1970); Spaargaren (1980); del Posso (1974)
2 Tijmons (?)
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F9.6 Porosity-morphology.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	simple	simple	unspecified								
2	dendritic	dendritic	simple								
3	open	closed	dendritic								
4	closed		open								
5			closed								
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); del Posso (1974)

2 Day (1983); Canada Department of Agriculture (1970)

3 Tijmons (?)

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F9.7 Porosity-type.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	vesicular	tubular	vesicular	spherical	unspecified						
2	interstitial	vacuolar	tubular	irregular	vesicular						
3	tubular	vesicular	irregular	tubular	tubular						
4		interstitial		ellipsoidal	interstitial						
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Day (1983); FAO (1986); Canada Department of Agriculture (1970); USDA (1976); Spaargaren (1980); del Posso (1974)

2 Maignien (1980)

3 Soil Conservation Service (1981)

4 Tijmons (?)

5 Tijmons (?)

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P10.1 Fissures - abundance (planes/10 cm).

Definition: fissures are planar pores with accordant surfaces, subdivided into smooth walled and rough walled. They form by drying out and shrinkage (Beckman et al, 1967).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<1										
2	1-4										
3	>4										
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Mc Keague et al (1986)

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3

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F10.2 Fissures - width (cm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<1	<3	<5	<0.2	<1						
2	1-3	3-10	5-10	0.2-0.5	1-2						
3	3-5	>10	10-20	0.5-2	2-5						
4	5-10		20-50	2-5	5-20						
5	>10		>50	5-10	20-50						
6				>10	>50						
7											
8											
9											
10											
11											
12											

<u>References</u>:

1 Hodgson (1976)

2 Kachinskii (1966)

3 Mc Donald et al (19849

4 Mc Keague et al (1986)

5 Benzler et al (1982)

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F11 Shrink-swell potential (COLE).

Definition: the shrink-swell potential is the susceptibility of soil to volume change due to loss or gain in moisture content. Classes are based on change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. This value, expressed as a decimal fraction is called COLE (coefficient of linear extensibility)(Soil Conservation Service, 1983).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<0.01	<0.03									
2	0.01-0.03	0.03-0.06									
3	0.03-0.06	0.06-0.09									
4	0.06-0.09	>0.09									
5	>0.09										
6											
7											
8											
9											
10											
11											
12											

References:

1 USDA (1971)

2 Soil Conservation Service (1983); Tijmons (?)

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P12.1 Consistence-stickiness.

Definition: stickiness is the quality of adhesion of the soil material to other objects. It is determined by noting the adherence of soil material when it is pressed between thumb and finger (FAO, 1977). The soil moisture content must be at, or slightly above, field capacity.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	non-sticky	non-sticky	unspecified								
2	slightly sticky	slightly sticky	non-sticky								
3	sticky	moderately sticky	slightly sticky								
4	very sticky	very sticky	sticky								
5			very sticky								
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Soil Conservation Service (1981); Van de Weg (1978); FAO (1986); Staring (1982); Day (1983); Maignien (1980); Jamagne (1967); Ilaco (1981); Spaargaren (1980); del Posso (1974)

2 Mc Donald et al (1984)

3 Tijmons (?)

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F12.2 Consistence-plasticity.

Definition: plasticity is the ability of soil material to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of the stress. It is determined by rolling the soil material between thumb and forefinger (FAO, 1977). The soil moisture content must be at, or slightly above fiel capacity.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	non plastic	non plastic	non plastic	unspecified							
2	slightly plastic	slightly plastic	very slightly plastic	non plastic							
3	plastic	moderately plastic	slightly plastic	slightly plastic							
4	very plastic	very plastic	plastic	plastic							
5			very plastic	very plastic							
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Soil Conservation Service (1981); Van de Weg (1978); FAO (1986); Staring (1982); Day (1983); Maignien (1980); Jamagne (1967); Ilaco (1981); Spaargaren (1980); del Posso (1974)

2 Mc Donald et al (1984)

3 Ministry of Agriculture and Forestry Japan (1955)

4 Tijmons (?)

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F12.3 Consistence-friability.

Definition: the friability is determined at a moisture content approximately midway between air dry and field capacity, by attempting to crush in the hand a mass of soil material that appears slightly moist (FAO, 1977).

Reference Classes	1	2	3	4	5*	6**	7	8*	9*	10*	Proposal
1	loose	loose	loose	loose/very friable	loose --	very friable	very friable	loose 0	very friable < 8	unspecified	
2	very friable	very friable	very friable and friable	friable	very friable < 8	friable > 2	friable	very weak < 8	friable 8-20	loose	
3	friable	slightly hard	firm	firm	friable 8-20	firm > 4	slightly hard	mod.weak 8-20	firm 20-40	very friable < 8	
4	firm	hard	very firm	very firm	firm 20-40	very firm > 8	hard	mod.firm 20-40	very firm 40-80	friable 8-20	
5	very firm	very hard extr.hard	extremely firm	extremely firm	very firm 40-80			very firm 40-80	extr.firm 80-160	firm 20-40	
6	extremely firm							mod.strong 80-160	extr.hard 160-800	very firm 40-80	
7								very strong 160-800		extr.firm 80-160	
8								rigid > 800		extr.hard 160-800	
9											
10											
11											
12											

5*, 8*, 9*, 10* Force under which specimen fails (N).
6** Applicated force (kg).

References:

1 FAO (1977); Soil Conservation Service (1981); Van de Weg (1978); Soil Conservation Service(1979); Ilaco(1981); Spaargaren(1980); del Posso(1974)
2 Braun et al (1977)
3 FAO (1986)
4 Staring (1982)
5 Day (1983); Jamagne (1967); Ballantyne (1962)
6 Maignien (1980)
7 ORSTOM (1969)
8 Hodgson (1976)
9 Mc Keague et al (1986)
10 Tijmons (?)

F12.4 Consistence-fragility.

Definition: fragility is the resistance to breaking or deformation (McDonald et al, 1984). It is described by attempting to break an air-dry mass between thumb and forefinger or in the hand.

Reference Classes	1*	2	3	4	5*	6**	7	8*	9*	10	Proposal
1	loose	loose	loose	loose	loose	soft	soft	soft	unspecified		
2	soft <8	soft	soft	soft	soft <8	slightly hard >4	slightly hard	slightly hard 8-40	loose		
3	slightly hard 8-40	slightly hard	slightly hard	slightly hard	slightly hard 8-40	hard >8	hard	hard 40-80	soft < 8		
4	hard 40-80	hard	somewhat hard	very hard	hard 40-80	very hard >16	very hard	very hard 80-160	slightly hard 8-20		
5	very hard 80-160	very hard	hard	extremely hard	very hard 80-160		extremely hard	extr.hard 160-800	slightly hard 20-40		
6	extr. hard 160-800		very hard		extr. hard 160-800				hard 40-80		
7			extremely hard		rigid >800				very hard 80-160		
8									extr. hard 160-800		
9											
10											
11											
12											

1*, 5*, 8*, 9* force under which specimen fairs (N).
6** applicated force (kg).

References:

1 FAO (1977); Soil Conservation Service (1981); Mc Donald et al (1984); Van de Weg(1978); FAO(1986); Ilaco(1981); Spaargaren(1980); del Posso(1974)

2 Braun et al (1978); Ballantyne (1962)

3 Soil Conservation Service (1969)

4 Staring (1982)

5 Day (1983)

6 Maignien (1980); Orstom (1969)

7 Jamagne (1967)

8 Mc Keague et al (1986)

9 Tijmons (?)

10

F12.5 Consistence-smeariness.

Definition: the extent to which a soil exhibits smeariness determines whether or not it is thixotropic. Thixotropy is the property exhibited by various gels of becoming fluid when disturbed and of setting again to a gel when allowed to stand. In evaluating thixotropic soil material, force is applied to a standard test specimen at field moisture capacity until it smears (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	weakly smeary	weakly	non-thixotropic								
2	moderately smeary	strongly	slightly thixotropic								
3	strongly smeary										
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Soil Conservation Service (1981)

2 Soil Conservation Service (1979)

3 FAO (1986)

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F12.6 Consistence-fluidity.

Definition: fluidity refers to the property of some soils to behave like liquids and flow under pressure. In evaluating fluidity a roughly egg-shaped specimen about 4 cm by 8 cm (a handful) is squeezed at the common natural moisture content. The amount of material that flows through the fingers determines the class (Soil Conservation Service, 1981).

Reference Classes	1*	2	3	4	5	6	7	8	9	10	Proposal
1	slightly n=0.7-1.0	slightly									
2	very n≥1	moderately									
3		very									
4											
5											
6											
7											
8											
9											
10											
11											
12											

1* the n value expresses the relation between the percentage of water under field conditions and the percentages of inorganic clay and humus.

References:

1 Soil Conservation Service (1981)

2 FAO (1986); Hodgson (1976)

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F13.1 Concentrations within the matrix-abundance (% volume). Definition: concentrations within the matrix are identifiable bodies embedded in the soil. They may contrast sharply with the surrounding material in strength, composition or internal organization (Soil Conservation Service, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<5	0	<2	<2	<1	<2	<20	0-2	<1		
2	5-15	<2	2-20	2-20	1-10	2-20	20-50	2-5	1-2		
3	15-40	2-10	>20	20-50	>10	20-40	>50	5-15	2-5		
4	40-80	10-20		>50		>40		15-50	5-10		
5	>80	20-50						50-80	10-30		
6		>50						>80	>30		
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); Spaargaren (1980); del Posso (1974)

2 Mc Donald et al (1984)

3 Day (1983); Soil Conservation Service (1981); Tijmons (?)

4 ORSTOM (1969)

5 Kohl (1971)

6 Hodgson (1976)

7 Von M Harmse (1984)

8 FAO (1986)

9 Benzler et al (1982)

10

F13.2 Concentrations within the matrix-size (mm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<10	< 2	< 5	< 1	< 1	< 1	< 2	< 2	< 2	< 2	
2	>10	2-6	5-15	1-2	1-3	1-2	2-5	2-10	2-5	2-5	
3		6-20	>15	2-5	>3	2-5	5-20	>10	5-20	5-10	
4		20-60		5-20		5-15	20-76		>20	10-20	
5		>60		20-76		>15	>76			20-100	
6				>76						> 100	
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); del Posso (1974)

2 Mc Donald et al (1984)

3 Day (1983); ORSTOM (1969); Maignien (1980); FAO (1986)

4 Soil Conservation Service (1979)

5 Kohl (1971)

6 Hodgson (1976)

7 Soil Conservation Service (1981)

8 Spaargaren (1980)

9 Tijmons (?)

10 del Posso (1974)

F13.3 Concentrations within the matrix-hardness.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	soft	soft	soft	soft							
2	hard	friable	hard	firm							
3		firm	indurated	indurated							
4		hard									
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); ORSTOM (1969); Spaargaren (1980); del Posso (1974)

2 Kohl (1971)

3 Von M.Harmse (1984)

4 FAO (1986)

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P13.4 Concentrations within the matrix - shape.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	spherical	spherical	cylindrical	irregular	rounded	spherical	spherical				
2	irregular	oblong	dendritic	oval	cylindrical	irregular	irregular				
3	angular	irregular	round	rounded	plate-like	angular	plate-like				
4		plate-like	platy		irregular	thread-like	tubular				
5			threads			dendritic					
6			irregular			cylindrical					
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); Spaargaren (1980); del Posso (1974)

2 Day (1978)

3 Soil Conservation Service (1979)

4 Kohl (1971)

5 Hodgson (1976); Soil Conservation Service (1981)

6 FAO (1986)

7 Tijmons (?)

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F13.5 Concentrations within the matrix - type.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	crystals	concretions	concretions	crystals	concretions	concretions	crystals				
2	soft concentrations	nodules	nodules	nodules	nodules	nodules	nodules				
3	concretions	crystals	casts	concretions	crystals	pedodes	concretions				
4	nodules	soft segregations		soft concentration	soft accumulation	crystals	sheet				
5		veins			soft rock fragments	soft segregations					
6		tubules			plinthite	not specified					
7		laminae									
8		cutans									
9											
10											
11											
12											

References:

1 Soil Conservation Service (1979)

2 Mc Donald et al (1984)

3 Day (1983)

4 Hodgson (1976)

5 Soil Conservation Service (1981)

6 FAO (1986)

7 Tijmons (?)

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F13.6 Concentrations within the matrix - composition.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	iron	carbonate	barite	carbonate	unidentified	iron	unidentified	iron	gypsum		
2	manganese	gypsum	calcareous	clay	calcium magnesium	iron-manganese	calcium carbonate	carbonate	calcite		
3	gibbsite	manganese	carbonate	gypsum	oxides & hydroxides	manganese	calcareous	gypsum	gibbsite		
4	lime-silica	iron-manganese	casts	silica	efflores-cence	carbonate	gypsum	manganese	ironstone		
5	lime	iron	clay	iron			ferri-manganiferous	silica	iron-manganese		
6	gypsum	aluminium	dark bodies	manganese			ferruginous	others	clay		
7	salt	sulphur	gibbsite	salt			sodium chloride				
8	unknown	visible salt	gypsum								
9	others	humified	iron								
10		iron-organic	manganese								
11		clay	salt								
12		others	silica								

References:

1 FAO (1986)

2 Mc Donald et al (1984)

3 Soil Conservation Service (1979)

4 Soil Conservation Service (1984)

5 ORSOTM (1969)

6 Kohl (1971)

7 Hodgson (1976)

8 Van de Weg (1978)

9 Tijmons (?)

10

F14.1 Cementation - degree.

Definition: cementation refers to a brittle, hard consistente caused by cementing substances other than clay minerals and which may affect all or part of a soil horizon. Descriptions of cementation imply that the condition alters little, if any with changes in the moisture content of the soil (Day, 1983 and FAO, 1977).

Reference Classes	1	2*	3	4	5	6	7	8	9	10	Proposal
1	weakly	weakly	slightly	pulveres-cence	uncemented	very weakly	slightly	weakly			
2	strongly	strongly	cemented	weakly	very weakly	weakly	cemented	moderately			
3	very strongly	indurated	strongly	moderately	weakly	strongly	strongly	strongly			
4			very strongly	strongly	strongly	very strongly					
5					indurated						
6											
7											
8											
9											
10											
11											
12											

2* Force under which specimen fails: <8,8-80 and >80 N respectively

References:

1 FAO (1977)

2 Van de Weg (1978); Day (1983); Tijmons (?)

3 Maignien (1969)

4 Maignien (1980)

5 Soil Conservation Service (1979)

6 Hodgson (1976)

7 Jamagne (1967)

8 del Posso (1974)

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F14.2 Cementation - extent.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	continuous over 1 m	continuous									
2	discon-tinuous over 1 m	discon-tinuous									
3		broken									
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Day (1983); Tijmons (?)

2 del Posso (1974)

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F15.1 Cemented pans - continuity.

Definition: cemented pan is a nearly continuous layer of indurated or strongly cemented material having a hard brittle consistency because the particles are held together by cementing substances (Soil Conservation Service, 1983).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	continuous										
2	discontinuous										
3	broken										
4											
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Mc Donald et al (1984); FAO (1986); del Posso (1974)

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P15.2 Cemented pans - structure.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	massive	massive									
2	vesicular	vesicular									
3	pisolitic	pisolitic									
4	nodular	nodular									
5	platy	platy									
6		vermicular									
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); FAO (1986); del Posso (1974)

2 Mc Donald et al (1984)

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F15.3 Cemented pans - cementation.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	uncemented	non-cemented									
2	weakly	weakly									
3	moderately	strongly									
4	strongly	very strongly									
5	very strongly										
6											
7											
8											
9											
10											
11											
12											

References:

1 Mc Donald et al (1984)

2 FAO (1986)

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F15.4 Cemented pans - type.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	plough pan	no pan	duripan	plough pan							
2	fragipan	calcrete	petrocalcic horizon	thin iron pan							
3	petrocalcic horizon	silcrete	petrogypsic horizon	iron pan							
4	iron pan	redbrown hardpan	placic horizon	calcrete							
5	indurated plinthite	duripan	sulphuric horizon	petrocalcic horizon							
6	duripan	fragipan	fragipan	duripan							
7	gypsum pan	clensipan	ironstone pan	silcrete							
8	salt pan	iron pan		fragipan							
9		sesquioxide pan		clay pan							
10		manganiferous pan		petrogypsic horizon							
11		ortstein		duricrust							
12		coffee rock other pans									

References:

1 FAO (1986)

2 Mc Donald et al (1984)

3 Ilaco (1981)

4 Hodgson (1978)

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F16.1 Roots - abundance.

Definition: roots-abundance refers to quantity classes of roots, which are defined in terms of numbers of each size per area (Soil Conservation Service, 1981).

Reference Classes	1 mm apart	2* dm^2	3 dm^2	4** dm^2	5** dm^2	6 dm^2	7 dm^2	8 dm^2	9 %exposed surf.	10 ft^2	Proposal
1	>100	0	1-10	0	0	0	<1	0	<2	<10	
2	50-100	0 1-10	10-50	1-10	<50	1-15	1-50	1-2	2-20	10-100	
3	20-50	1-2 10-25	50-200	10-50	50-150	15-50	50-200	2-5	>20	>100	
4	10-20	2-5 25-200	>200	50-150	>150	50-200	>200	5-10			
5	5-10	>5 >200		>150		>200		10-20			
6	<5	-						20-50			
7								>50			
8											
9											
10											
11											
12											

2* very fine and fine roots and medium and coarse roots respectively.
4**, 5**: 4** is description of horizon, 5** of the whole soil profile.

References:

1 Van de Weg (1978)

2 Mc Donald et al (1984); Hodgson (1976)

3 FAO (1986)

4 Maignien (1980)

5 Maignien (1980)

6 ORSTOM (1969)

7 Canada Department of Agriculture (1970)

8 Kohl (1971)

9 All India Soil and Land Use Survey Organization (1971)

10 Laing (1976)

F16.1 Roots - abundance. (cont.)

Reference Classes	11* dm^2	12 ft^2	13	14	15	16	17	18	19	20	Proposal
1	<100	1-3	1-2								
	<1										
2	100-500	4-20	3-5								
	1-5										
3	>500	20-100	6-10								
	>5										
4		>100	11-20								
5			21-50								
6			> 50								
7											
8											
9											
10											
11											
12											

11* very fine and fine roots and medium and coarse roots respectively.

References:

11 Soil Conservation Service (1981)

12 Clarke et al (1971)

13 Benzler et al (1982)

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F16.2 Roots - size (mm).

Reference Classes	1	2	3	4	5	6	7	8 inches	9	10	Proposal
1	1	micro	1	0.075	network of fine roots	1	3	1/32	0.5		
2	1-2	1	1-2	0.075-1	10	1-2	3-6	1/32-1/8	0.5-2		
3	2-5	1-2	2-5	1-2	10	2-5	6	1/8-1/2	2-5		
4	5	2-5	5-20	2-5		5-10		1/2	5		
5		5	20	5		10					
6											
7											
8											
9											
10											
11											
12											

References:

1 FAO (1977); Van de Weg (1978); Mc Donald et al (1984); FAO (1986); Hodgson (1976); Soil Conservation Service(1981); Spaargaren(1980); del Posso(1974)

2 Day (1983)

3 Maignien (1980); ORSTOM (1969)

4 Canada Department of Agriculture (1970)

5 Jamagne (1967)

6 All India Soil and Land Use Survey Organization (1971)

7 Ballantyne (1962)

8 Clarke et al (1971)

9 Tijmons (?)

10

F16.3 Roots - orientation.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	vertical	unidentified									
2	horizontal	vertical									
3	oblique	horizontal									
4	random	oblique									
5		random									
6											
7											
8											
9											
10											
11											
12											

References:

1 Day (1983); Canada Department of Agriculture (1970); Tijmons (?)

2 Maignien (1980); ORSTOM (1969)

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F16.4 Roots - distribution.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	inped	in cracks	inped								
2	exped	in mat top ref. hor.	exped								
3		between peds	matted around peds, stones								
4		matted around stones or gravel									
5		throughout horizon									
6											
7											
8											
9											
10											
11											
12											

References:

1 Day (1983); Canada Department of Agriculture (1970)

2 Soil Conservation Service (1979); FAO (1986)

3 Maignien (1980)

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F17.1 Effervescence - degree.

Definition: effervescence is the building, hissing or foaming noticed when a chemical reagent is added to a sample of soil. It is caused mainly by carbonates and manganese oxides, or sometimes by organic matter (Day, 1983).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	very weak	very slight	none	no detectable	none	none	no	none			
2	weak	slight	slight	slight	weak	slight	very faint	weak			
3	moderate	strong	strong	moderate	noticeable	vigorous	faint	moderate			
4	strong	violent	violent/ very strong	high	violent	very vigorous	distinct	strong			
5				very high			vigorous				
6											
7											
8											
9											
10											
11											
12											

References:

1 Day (1983); Canada Department of Agriculoture (1970); Tijmons (?)

2 Soil Conservation Service (1981)

3 Van de Weg (1978); FAO (1977); Soil Conservation Service (1979); Spaargaren (1980); del Posso (1974)

4 Mc Donald et al (1984)

5 Ferrari et al (1965)

6 Carvalho Cardoso (1972)

7 Ilaco (1981)

8 Maignien (1980)

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F17.2 Effervescence - location.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	general										
2	matrix										
3	large particules										
4	secondary elements										
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Maignien (1980)

2

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F18.1 Acidity - pH_{H_2O}

Definition: the pH value equals the negative logarithm of the H-ion concentration (ranging from 10^{-1} to 10^{-12} mol/lit) (Ilaco, 1981). Conventionnaly, the soil pH is measured in a soil:water suspension.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<4.5	<4.5	5.5-7.5	<3.9	<4.5	<4.5	<5.0	4.0-5.5	6.5-7.5	<5.0	
2	4.5-5.0	4.5-5.0	5.0-8.0	3.9-5.4	4.6-5.0	4.5-6.5	5.0-6.5	5.5-6.0	7.5-8.0	5.0-6.5	
3	5.1-5.5	5.1-5.5	4.5-8.5	5.5-6.5	5.1-5.5	>6.5	6.5-7.5	6.0-6.5	5.5-6.5; 8.0-8.5	6.5-7.5	
4	5.6-6.0	5.6-6.0	4.0-9.0	6.6-8.5	5.6-6.0		>7.5	6.5-7.0	5.0-5.5; 8.5-9.0	7.5-8.5	
5	6.1-6.5	6.1-6.5	<4.0; >9.0	unknown	6.1-6.5			7.0-9.0	<5.0; >9.0	>8.5	
6	6.6-6.9	6.6-7.3			6.6-7.3			<4.0; >9.0			
7	7.0	7.4-7.8			7.4-7.8						
8	7.1-7.3	7.9-8.4			7.9-8.4						
9	7.4-7.8	8.5-9.0			≥8.5						
10	7.9-8.4	>9.0									
11	8.5-9.0										
12	>9.0										

References:

1 Ilaco (1981)

2 Soil Conservation Service (1981); Van de Weg (1978); Tijmons (?) del Posso (1974)

3 Staring (1982)

4 Shields (1986)

5 Day (1983)

6 Haans (1979)

7 Young (1983)

8 INRA/CEE (?)

9 Mori et al (1983)

10 Maignien (1980)

F18.1 Acidity - pH_{H_2O} (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	<3.5	<4.9	<5.5								
2	3.5-4.4	5.0-6.6	5.5-7.0								
3	4.5-5.0	6.7-7.3	7.0-8.0								
4	5.1-5.5	7.4-8.7	>8.0								
5	5.6-6.0	>8.7									
6	6.1-6.5										
7	6.6-7.3										
8	7.4-7.8										
9	7.9-8.4										
10	8.5-9.0										
11	>9.0										
12											

References:

11 Soil Conservation Service (1983)

12 Segalen (1984)

13 Landon (1984)

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P18.2 Acidity - pH_{KCl}.

Definition: for the measurement of the so-called exchange (also called reserve or potential) acidities of an acid soil a 1:2½ suspension to which a neutral salt (KCl) has been added, in order to bring exchangeable H-ions into solution, is used.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 4.0										
2	4.0-4.5										
3	4.5-5.0										
4	> 5.0										
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Centre for World Food Studies (1985)

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F19 Bulk density (gr/cm^3).

Definition: moist bulk density is the ovendried weight of the 2 mm material per unit volume of soil, exclusive of rock fragments 2 mm or larger. The weight applied is that of the ovendry soil and the volume applies to the soil at or near field capacity (Soil Conservation Service, 1983).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<1.0	≤ 0.95	<0.7								
2	1.0-1.5	0.96-1.2	0.7-0.95								
3	1.5-2.0	1.3-1.5	0.95-1.2								
4	>2.0	>1.5	1.2-1.5								
5			>1.5								
6											
7											
8											
9											
10											
11											
12											

References:

1 Ilaco (1981)

2 Shields (1986)

3 Sombroek (1986)

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P20.1 Organic matter - abundance (%).

Definition: soil organic matter is the organic fraction of the soil that includes plant and animal residus at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population; commonly determined as the amount of organic matter contained in less than 2 mm soil material (Soil Conservation Service, 1983).

Reference Classes	1	2	3	4	5*	6	7	8	9	10	Proposal
1	<1.0	0.5-1.8	0-0.4	<6	<1	2-5	17-35	<8	8-13		
2	1.0-2.0	1.8-3.5	0.4-1	6-20	<1 1-2	5-10	35-50	8-13	13-25		
3	2.1-4.2	3.5-8	1-2	20-30	1-2 2-4	10-20	>50	13-20	25-40		
4	4.3-6.0	8-12.5	2-4		2-5 4-8	>20		>20	>40		
5	>6.0	12.5-25	4-10		5-10 8-15						
6			10-20		10-15 15-30						
7					15-30 >30						
8					>30						
9											
10											
11											
12											

5* farmland and woodland respectively.

References:

1 Ilaco (1981)

2 Jamagne (1967)

3 Godron et al (1968)

4 Maignien (1969)

5 Kohl (1971); Benzler et al (1982)

6 Ministry of Agriculture and Forestry, Japan (1955)

7 Taylor et al (1962)

8 Bown (1973)

9 Clarke et al (1971)

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F20.2 Organic matter - kind.

Definition: the kind of organic matter is the physical nature and composition of the various substances from which the plant is formed and the nutrients contained with them (Hodgson, 1978).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	sedimentary peat	leaves	moss peat	raw humus	raw humus	mull	muck				
2	moss peat	needles	herbaceous peat	mild humus	peaty	silicate moder	peat				
3	herbaceous peat	sphagnum	woody peat	intimate humus	shallow peat	raw humus	raw humus & mor				
4	woody peat	feather moss	coprogenous earth	mech.incop. org.matter	deep peat		moder				
5	mucky peat	sedges and reeds	litter		moder peat		mull				
6	muck	herbaceous fragments			anmoorig						
7		wood fragments			sapro-humus						
8		coprogenous earth			mull rich						
9					humus rich						
10					humus poor						
11											
12											

References:

1 Soil Conservation Service (1981)

2 Day (1983)

3 FAO (1986)

4 Clarke et al (1971)

5 Jäggli et al (1977)

6 Bown (1973)

7 Sys (1961)

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F20.3 Organic matter - decomposition.

Reference Classes	1*	2**	3***	4	5	6	7	8	9	10	Proposal
1	<10	<10	-								
2	10-40	10-50	<25								
3	>40	>50	25-40								
4	-	-	40-55								
5			55-70								
6			>70								
7											
8											
9											
10											
11											
12											

1* % rubbed fiber
2** % fibric or foliated matter
3*** % fine residues

References:

1 Day (1983)

2 Segalen et al (1984)

3 Fitzpatrick (1980)

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F21 Organic carbon (%).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-0.6	<0.3	<0.5	<0.6	<0.5	<4	<2				
2	0.7-2	0.3-0.5	0.5-1	0.6-1.25	0.5-1	4-10	2-4				
3	2.1-3	0.5-1.0	1-2	1.26-2.5	1-2	>10	4-10				
4	3.1-8	1.0-2.5	2-4	2.51-3.5	2-2.5		10-20				
5	8.1-17	>2.5	4-8	>3.5	2.5-3		>20				
6			8-15		>3						
7			>15								
8											
9											
10											
11											
12											

References:

1 Shields (1986)

2 Staring (1982)

3 Schroeder (1984)

4 Ilaco (1981)

5 Centre for World Food Studies (1985)

6 Landon (1984)

7 Metson (1961)

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P22 Nitrogen (% soil by weight).

Definition: nitrogen is one of the essential elements for normal growth of plants and animals. It is a constituent of protein and encourages vegetative growth in plants (Walker, 1983).

Reference Classes	1	2*	3	4	5	6	7	8	9	10	Proposal
1	0.1	20									
2	0.1-0.2	20-40									
3	0.2-0.5	40-60									
4	0.5-1.0	60-80									
5	1.0	80-100									
6											
7											
8											
9											
10											
11											
12											

2* ppm N

References:

1 Metson (1961)

2 Ilaco (1981)

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P23 C/N ratio.

Definition: C/N ratio is the ratio of the weight of organic carbon to the weight of total nitrogen in a soil or organic material (Walker, 1983). The C/N ratio is commonly quoted as indication of the type of organic matter present and in particular the degree of humification (Landon, 1984).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<8	<10									
2	8-10	10-15									
3	11-15	15-20									
4	16-25	20-25									
5	>25	>25									
6											
7											
8											
9											
10											
11											
12											

References:

1 Ilaco (1981)

2 Benzler et al (1982)

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F24 Salinity-ECe(mmhos/cm).

Definition: the electrical conductivity at 25°C of a saturated extract (ECe), is the standard measure of salinity (Soil Conservation Service, 1983).

Reference Classes	1	2	3	4	5	6*	7	8	9	10	11	Proposal
1	0-4	<4	0-4	0-4	<4	<2 <4	0-2	4-8	0-4	2-4	0-2	
2	4-8	4-8	5-8	4-8	4-8	2-4 4-8	2-4	8-15	4-8	4-8	2-8	
3	8-15	8-16	9-15	8-15	>8	4-8 8-15	4-8	>15	8-16	8-15	8-15	
4	>15	16-24	16-25	15-30		8-15 16-24	8-16		>16	>15	>15	
5		>24	>25	>30		≥16 ≥24	16-24					
6												
7												
8												
9												
10												
11												
12												

6* 0-30 cm & 30-120 cm respectively.

References:

1 FAO (1977); Ilaco (1981); FAO (1986); Maignien (1980)

2 Staring (1982)

3 Shields (1986)

4 Van de Weg (1978)

5 Andriesse et al (1985)

6 Braun et al (1977); Beek et al (1979)

7 Shields (1985)

8 Day (1983)

9 Soil Conservation Service (1981, 1983); Tijmons (?)

10 Fitzpatrick (1983)

11 U.S. Salinity Lab. Staff (1954)

F25 Sodicity-SAR (meq/lit).

Definition: the sodium adsorption ration (SAR) is the standard measure of the sodicity of a soil. The SAR ratio is calculated from the concentrations (meq/lit) of sodium, calcium and magnesium in the saturation extract.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-2										
2	2-5										
3	5-12										
4	12										
5											
6											
7											
8											
9											
10											
11											
12											

References:

1 Tijmons (?)
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F26 **Exchangeable Sodium Percentage-ESP (%).** Definition: the Exchangeable Sodium Percentage (ESP) is the fraction of the cation exchange capacity of a soil occupied by sodium ions, expressed as a percentage (Soil Science Society of America, 1984).

Reference Classes	1	2	3*	4	5	6	7	8	9	10	Proposal
1	<5	<6	<6 <15	<6	<6	<5	<20	<15	2-10		
2	5-15	6-15	6-15 15-30	6-15	7-15	5-10	20-50	15-25	10-20		
3	15-25	15-30	15-30 30-50	>15	16-30	10-20	>50	>25	20-40		
4	25-45	30-50	30-50 >50		31-60	20-30			40-60		
5		>50	>50		>60	>30			60		
6											
7											
8											
9											
10											
11											
12											

3* 0-30 cm, 30-100 cm respectively.

References:

1 FAO (1986)

2 Van de Weg (1978)

3 Braun et al (1977)

4 Andriesse et al (1985)

5 Shields (1986)

6 Staring (1982)

7 Fitzpatrick (1983)

8 Landon (1984)

9 Bower (1959)

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F27 Carbonates (% by weight).

Definition: carbonates classes are estimated in the field on the amount of carbonates present, expressed as $CaCO_3$ equivalent. An approximation of the class can be made by noting the effervescence obtained with 10% HCl (see property F17). These approximations should be confirmed by measurements in the laboratory (Day, 1983).

Reference Classes	1	2	3	4	5	6	7*	8	9	10	Proposal
1	<5	1-2	<5	<5	<2	<2	0	0-2	<5	< 0.5	
2	5-15	2-10	5-15	5-10	2-10	2-15	0 < 0.2	2-4	5-10	0.5-1	
3	15-25	10-20	15-25	10-15	0-25	15-30	< 0.4 0.2-1	4-7	>10	1-5	
4	25-40	20-50	>25	15-25	25-55	30-60	0.4-1.5 1-10	7-10		5-10	
5	>40	>50		>25	>55	>60	1.5-10 10-20	>10		> 10	
6							10-20 >20				
7							>20				
8											
9											
10											
11											
12											

7* for light soils and heavy soils respectively.

References:

1 Day (1983); Maignien (1980); Canada Department of Agriculture (1970); Tijmons (?)
2 Schroeder (1984)
3 INRA/CEE (?)
4 Mori et al (1983)
5 Jamagne (1967)
6 ORSTOM (1969)
7 Kohl (1971)
8 Szabolcs (1966)
9 Carvalho Cardoso (1972)
10 Hodgson (1976)

F27 Carbonates (% by weight). (cont.)

Reference Classes	11	12	13	14	15	16	17	18	19	20	Proposal
1	< 0.5	< 0.1	0								
2	0.6-1.5	0.1-0.5	< 0.5								
3	1.6-2.5	0.5-1.0	0.5-2								
4	2.6-5.0	1.0-2.0	2-4								
5	5.1-10	2.0-5.0	4-7								
6	11-20	5.0-10.0	7-10								
7	21-40	> 10.0	10-25								
8	> 40		25-50								
9			> 50								
10											
11											
12											

References:

11 Ilaco (1981)

12 Clarke et al (1971)

13 Benzler et al (1982)

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F28 Gypsum (% by weight). Definition: Gypsum is a crystalline hydrated sulphate of calcium ($CaSO_4 \cdot H_2O$).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<2										
2	2-25										
3	>25										
4											
5											
6											
7											
8											
9											
10											
11											
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References:

1 Van Alphen et al (1971)

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F29.1 Cation Exchange Capacity - soil (meq/100gr soil).

Definition: the cation exchange capacity (CEC) is the total potential of soils for adsorbing cations expressed in meq/100 gr soil. Determined values depend somewhat upon the method employed (Fitzpatrick, 1983).

Reference Classes	1	2	3*	4	5	6	7	8	9	10	Proposal
1	< 3	0-2	< 6	< 1	< 5						
2	3-6	3-10	6-12	1-2	5-15						
3	6-12	11-30	13-25	2-3	15-25						
4	12-20	31-60	26-40	3-8	25-40						
5	> 20	unknown	> 40	8-14	> 40						
6				> 14							
7											
8											
9											
10											
11											
12											

3* $CEC_{8.2}$

References:

1 Staring (1982)

2 Shields (1986)

3 Ilaco (1981)

4 Centre for World Food Studies (1985)

5 Landon (1984)

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F29.2 Cation Exchange Capacity - clay (meq/100 gr).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 1.5	< 30									
2	1.5-6.0	30-40									
3	6.0-16	40-50									
4	16-36	50-60									
5	>36	>60									
6											
7											
8											
9											
10											
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References:

1 Sombroek (1986)

2 Benzler et al (1982)

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F31 Base Saturation (%).

Definition: the total quantity of the four exchangeable cations Ca, Mg, K and Na can be related the Cation Exchange Capacity value and expressed as the base saturation percentage. (Ilaco, 1981).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<40	<20	0-50	<15	0-10	<20					
2	40-55	21-40	50-100	15-35	10-25	20-60					
3	55-75	41-60	unknown	35-50	25-50	>60					
4	>75	61-80		50-75	50-75						
5		81-100		>75	75-100						
6											
7											
8											
9											
10											
11											
12											

References:

1 Centre for World Food Studies (19859

2 Ilaco (1981)

3 Shields (1986)

4 Staring (1982)

5 Sombroek (1986)

6 Landon (1984)

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F32 Exchangeable Calcium (meq/100 gr soil).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<2	<4									
2	2-5	4-10									
3	5-10	>10									
4	10-20										
5	>20										
6											
7											
8											
9											
10											
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References:

1 Ilaco (1981)

2 Landon (1984)

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F33 Exchangeable Magnesium (meq/100 gr soil).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 0.5	< 0.5	< 0.2								
2	0.5-1.5	0.5-4.0	0.2-0.5								
3	1.5-3.0	> 4.0	> 0.5								
4	3-8										
5	> 8										
6											
7											
8											
9											
10											
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References:

1 Ilaco (1981)

2 Landon (1984)

3 MAFF (1967)

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F35 Exchangeable Sodium.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<0.1										
2	0.1-0.3										
3	0.3-0.7										
4	0.7-2.0										
5	>2.0										
6											
7											
8											
9											
10											
11											
12											

References:

1 Ilaco (1981)

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F34 Exchangeable Potassium (meg/100 gr soil).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 0.1	< 0.05	< 0.2	0.03-0.2	0.3-0.5	< 0.15					
2	0.1-0.3	0.05-0.1	0.2-0.6	0.2-0.4	0.5-0.8	0.15-0.6					
3	0.3-0.6	0.1-0.2	> 0.6	0.4-0.8	> 0.8	> 0.6					
4	0.6-1.2	0.2-0.4									
5	> 1.2	0.4-1.0									
6		> 1.0									
7											
8											
9											
10											
11											
12											

References:

1 Ilaco (1981)

2 Centre for World Food Studies (1985)

3 Landon (1984)

4 Young et al (1962)

5 Metson (1961)

6 MAFF (1967)

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F36 Exchangeable aluminium (%).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	< 30										
2	30-85										
3	> 85										
4											
5											
6											
7											
8											
9											
10											
11											
12											

<u>References</u>:

1 Landon (1984)

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F37 Available phosphorus (ppm).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	<5	<3									
2	5-15	3-6.5									
3	>15	6.5-13									
4		13-22									
5		>22									
6											
7											
8											
9											
10											
11											
12											

References:

1 Olson et al (1965)

2 As interpreted in Min. of Agriculture, Zimbabwe

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ANNEX 1

A6.1 Slope-length (m).

Definition: The actual length of a slope, measured on its surface from the higher to the lower point, and not by its projection on to a plane (as on a map), which is the horizontal equivalent (Monkhouse et al, 1978).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-50	0-100 ft	0-50								
2	50-200	100-500 ft	50-150								
3	>200	500-1000 ft	150-300								
4		>1000 ft	300-600								
5			>600								
6											
7											
8											
9											
10											
11											
12											

References:

1 Braun et al (1977)

2 Shields (1985)

3 Sombroek (1986)

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A6.2 Slope-gradient (%).

Definition: slope gradient is the inclination of the surface of the soil from the horizontal. The difference in elevation between two points is expressed as a percentage of the distance between those points (Soil Conservation Service, 1981)

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-2	0-2	0-2	0-8	1-3	0-0.5	0-2	0-3	0-5	0-0.5	
2	2-8	2-5	2-6	8-16	4-9	0.5-2	3-8	3-8	5-10	0.5-2	
3	8-16	5-8	6-13	16-30	10-15	2-5	9-15	8-18	10-15	2-5	
4	16-30	8-16	13-25	30-70	16-30	5-9	16-30	18-30	15-30	5-9	
5	>30	16-30	>25	>70	31-61	9-15	31-55	30-45	30-50	9-15	
6		>30			>61	15-30	>55	>45	> 50	15-30	
7						30-45				30-60	
8						45-70				>60	
9						70-100					
10						>100					
11											
12											

References:

1 FAO (1977); del Posso (1974)

2 Van de Weg (1978); Andriesse et al (1985); Spaargaren (1980)

3 Staring (1982)

4 Braun (1977)

5 Shields (1985)

6 Day (1983); Maignien (1980)

7 FAO (1986)

8 Young (1983)

9 Mori et al (1983)

10 Canada Dept. of Agriculture (1970); Segalen et al (1984)

A6.2 Slope-gradient (%). (cont. 1)

Reference Classes	11	12	13	14	15*	16*	17*	18	19	20*	Proposal
1	0-2	0-1	0-5	0-1	0-2°	0-1°	0-5°	0-3	0-4	0-1°	
2	2-5	1-9	5-12	1-3	2-6°	1-3°	5-20°	3-8	5-10	2-3°	
3	5-10	9-25	12-17	3-5	6-12°	3-6°	>20°	8-15	11-15	4-7°	
4	10-15	25-49	17-25	5-10	12-20°	6-13°		15-25	16-20	8-11°	
5	15-25	49-100	25-45	10-15	20-25°	13-20°		25-40	21-25	12-15°	
6	>25	100-275	>45-65	15-25	>25°	20-28°		40-60	26-35	16-25°	
7		>275		25-33		28-38°		>60	36-45	26-35°	
8				33-50		>38°			46-55	>36°	
9				>50					56-75		
10									>75		
11											
12											

15*, 16*, 17*, 20* in degrees.

References:

11 Jamagne (1967).

12 Godron et al (1968)

13 Szabolcs (1966)

14 All India Soil and Land Use Survey Organization (1971)

15 Leamy et al (1966)

16 Taylor et al (1962)

17 Jenkin (1963)

18 Barrera (1961)

19 Jäggli et al (1977)

20 Hodgson (1976)

A6.2 Slope-gradient. (cont.2)

Reference Classes	21	22	23	24	25	26	27	28	29	30	Proposal
1	0-2	0-(1-3)	0-(1-3)	0-8	0-3	0-12	0-1	0-2	0-0.5	0-2	
2	2-5	(1-3)-(5-8)	(1-3)-(5-8)	8-30	4-8	12-19	1-3	2-5	0.5-1	2-7	
3	5-8	(5-8)-(10-16)	(5-8)-(8-16)	>30	9-15	19-47	3-20	5-8	1-10	7-12	
4	>8	(10-16)-(20-30)	(10-16)-(18-30)		16-30	>47	>20	8-12	10-15	12-18	
5		(20-30)-(45-65)	(20-30)-(30-60)		>30-60			>12	>15	>18	
6		>(45-65)	>(45-65)								
7											
8											
9											
10											
11											
12											

References:

21 Ballantyne (1962)

22 Soil Conservation Service (1983)

23 Soil Conservation Service (1983)

24 FAO-Unesco (1974)

25 Shields (1986)

26 Bibby et al (1969)

27 Short (1973)

28 Loxton (1962)

29 Digar et al (1960)

30 Klingebiel (1958)

A6.2 Slope gradient. (cont.3)

Reference Classes	31	32	33	34	35	36	37	38	39	40	Proposal
1	<1	0-3	0-2								
2	1-2	3-8	1-4								
3	2-3.5	8-20	3-6								
4	3.5-5	20-45	5-9								
5	5-9	45-75	8-20								
6	9-12	>75	15-30								
7	12-18		25-45								
8	18-27		>45								
9	27-36										
10	36-58										
11	>58										
12											

References:

31 Benzler et al (1982)

32 SNLCS (1979)

33 Tijmons (?)

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A6.3 Slope-form.

Definition: Slope-form refers to the configuration of the slope (Soil Conservation Service, 1979).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	concave	unknown	single								
2	linear	convex	undulating								
3	convex	plane	convex								
4		concave	concave								
5		undulating	concave-convex								
6		complex									
7											
8											
9											
10											
11											
12											

References:

1 Spaargaren (1980)

2 Soil Conservation Service (1979)

3 USDA (1951)

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A6.4 Slope-pattern.

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	uniform										
2	regular										
3	irregular										
4	single										
5	complex										
6											
7											
8											
9											
10											
11											
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References:

1 Spaaargaren (1980)

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A7.1 Elevation-median (m).

Definition: elevation is the height or altitude above some particular level, of specifically above some datum (Monckhouse et al, 1978).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-500	< 0									
2	500-1000	0-200									
3	1000-1500	201-500									
4	1500-2000	501-1500									
5	2000-2500	1501-3000									
6	> 2500	> 3000									
7	?										
8											
9											
10											
11											
12											

References:

1 Young (1983)

2 Environmental Systems Research Institute (1984)

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D5.1 Vegetation structure-spacing (folliage cover) (%).

Reference Classes	1	2	3	4	5	6	7	8	9	10	Proposal
1	0-5	0-1	0-5	4							
2	5-15	1-20	5-10	4-10							
3	15-30	20-40	10-25	10-25							
4	30-70	40-60	25-50	25-75							
5	>70	60-80	50-70	>75							
6		80-100	70-90								
7			>90								
8											
9											
10											
11											
12											

References:

1 Sombroek (1986)

2 FAO-UNEP-Unesco (1980)

3 Maignien (1980)

4 Hodgson (1976)

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