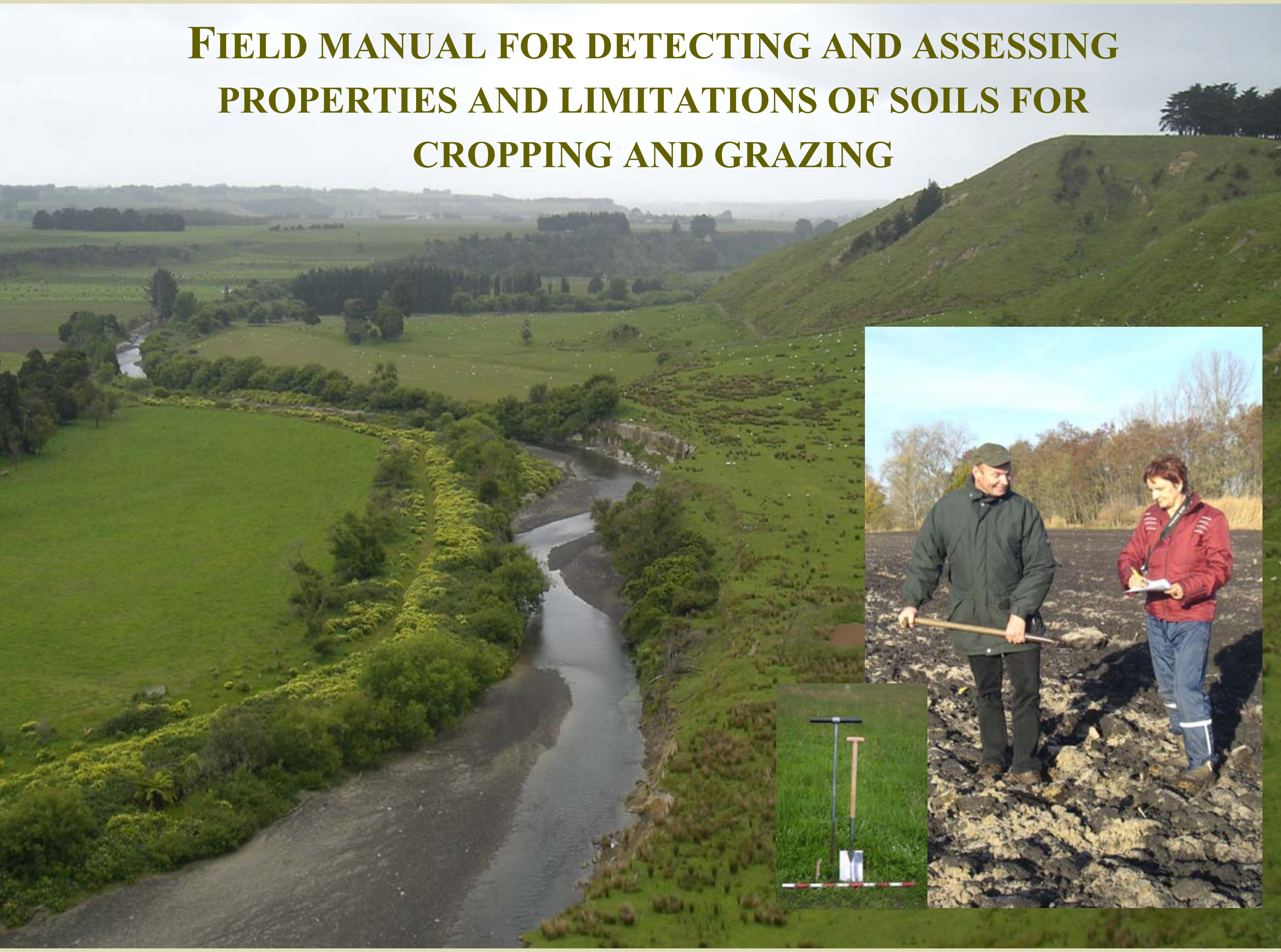
# The Muencheberg Soil Quality Rating (SQR)

## FIELD MANUAL FOR DETECTING AND ASSESSING PROPERTIES AND LIMITATIONS OF SOILS FOR CROPPING AND GRAZING

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## 1. Objectives

This manual shall provide guidance of soil quality (SQ) assessment for farming. Farmland is used to feed mankind in a sustainable manner. In this context, SQ may be characterised by the definition: "…the soil's fitness to support crop growth without becoming degraded or otherwise harming the environment "(Acton and Gregorich, 1995, in: Vigier et al., 2003).

During the past years many attempts have been undertaken to evaluate SQ in order to provide "*the soil's fitness or health*". They are focused on management induced aspects of SQ, mainly indicated by a favourable soil structure (INRA/ISTRO - report 2005).

However, *„fitness"* and *„health"* of a subject are not alone the result of a good management, but depend largely upon natural genetic constitution and age.

If common SQ ratings certify a fit and healthy looking soil to promise high yields, this may be erroneous. First is this rating not necessarily the result of proper management and second, the yield expectations may fail. A neighboured soil of more unfavourably looking soil structure and worser rating may possibly be higher in crop yield due to better crucial soil inherent properties like plant available water.

Soil inherent quality should also be taken into consideration when evaluating soil health. However, internationally comparable methods of the soil inherent quality assessment easy to handle are missing. Soil maps in different scales do exist, but they give only indirect hints on quality for cropping or grazing and for the crop yield potential.

The objective of this paper is to present a simple method for rating soil quality of farmland in the field - the Muencheberg SQR. The final result will be a semi-quantitative measure, e. g. a rating score between 1 and 100, of soil suitability for cropping or grazing.

This should provide comparative on-site assessment of the soil suitability for arable and grassland farming and estimation of the crop yield potential. In combination with methods of dynamic soil quality assessment, VSA (Shepherd, 2000), it will also provide recommendations for long-term sustainable use of soils and good agricultural practice. The frame of rating can further be utilised in decision support systems and scenarios of soil use.

Intended benefits of the method are:

- Reliable and fast field scoring of soil quality for farmland in terms of good, moderate, poor and very poor
- Field method, applicable for both extension and collegial contests
- Matching to procedures of dynamic soil quality assessment like VSA (Shepherd, 2000 or SoilPak (McKenzie, 2001)
- Valid for a range of soils over large regions
- Linkable with soil mapping units
- Correlation of final score with the crop yield potential within climatic sub-zones

Potential applications of the method are: Soil resource planning, guiding land purchase, and assessment of sustainability and environmental impacts of land use.

This manual is not valid for some extremely particular soil and cropping conditions:

- No paddy rice systems, no consideration of dual- or multi-cropping systems
- No consideration of direct climatic limitations and hazards of plant growth: frost, fire, wind
- No consideration of local typical risks for cropping like pests, weeds and diseases

**Basic principles underlying the manual**

- SQ ratings refer to current conditions of a soil pedon including the medium-term soil hydrological, thermal, geological and terrain conditions and the human impact (soil forming factors)
- SQ ratings are performed in the field and will yield in a real-time judgement without delay due to laboratory analyses. However, those analyses are recommended or necessary to validate the results.
- SQ ratings are restricted to soil's suitability for cropping and grazing. The focus is on rainfed cropping in temperate zones and rotations with dominance of cereals, mainly wheat.
SQ ratings for grassland have less focus on particular vegetation or management systems. Grassland ratings assume a minimum level of accessibility and management.
- SQ ratings are grown up on a common description of a soil profile.
- Matching tables will provide a fast orientation to commonly used current assessment of single indicators. These are mainly documented in: The FAO Guidelines for soil description (Guidelines for soil description, 2006) the German "Bodenkundliche Kartieranleitung"(AG Boden, 2005) and the U.S. National Soil Survey Handbook (USDA/NRCS (2005).
- Overall ratings are compatible with internationally acceptable methods of dynamic SQ ratings. These are mainly: Visual soil assessment methods of Shepherd, 2000, Mc Kenzie, 2001 and Munkholm, 2000, (in: INRA/ISTRO - report 2005), and the method of Peerlkamp, mod. by Batey and Ball, 2006 (in: INRA/ISTRO - report 2005).
- SQ indicators are ranked into an ordinal scale, empirically weighted and summarised. Such a procedure minimises, but does not eliminate, different individual judgement based on empirical appraisal. However, as the basis of assessment is documented, one can trace the evaluation back to soil characteristics and can evaluate the relevance of the ratings.
- A growing number of sample ratings (Appendix 1) will provide a data basis for the adjustment of individual ratings and the perpetued improvement of the framework and thresholds

## 2. Concept

The Muencheberg SQR method shall result in a final score of a given pedon within a 100 point scale. This score is a measure of the long-term soil quality and will provide a rough estimate of the local crop yield potential. A set of indicators will be scored in terms of good, medium or poor, will be weighted and summarised. Indicators will be estimated based on a description of main soil profile features with consideration of the topographical and hydrological position of the pedon. The basic soil scoring procedure is compatible with the VSA method (Shepherd, 2000) for the evaluation of the dynamic soil quality and gives hints at management deficits.
Basic soil indicators (Fig. 2.-1, Table 3.2.0.-1) are scored by using scoring tables. Single scores are on a quasi 5-ball scale ranking from best conditions (2) to worst (0) with possible increments of 0.5, or 0.25 in very sensitive cases. Basic soil indicators will be completely estimated in the field. They can be backed by measurements of soil properties.
The final basic score ranges from 0 (theoretical minimum, practical is about 15) to 34. It is a measure of soil quality for farming. Values less than 20 indicate poor soils, values greater than 27 are typical of good soils.

In a second step (Fig. 2.-1) the rating system does also consider hazard soil properties and indicators. These properties are so critical for farming that they may limit the total soil quality. Hazard soil properties are the result of extremes of soil forming factors, either in excess or in a minimum. They are often determined by climatic factors.
In many soils of the temperate zone the soil quality will not be limited by hazard soil factors. If the latter are present most of them can be identified by field methods or with simple field tool kits or by indicator vegetation.

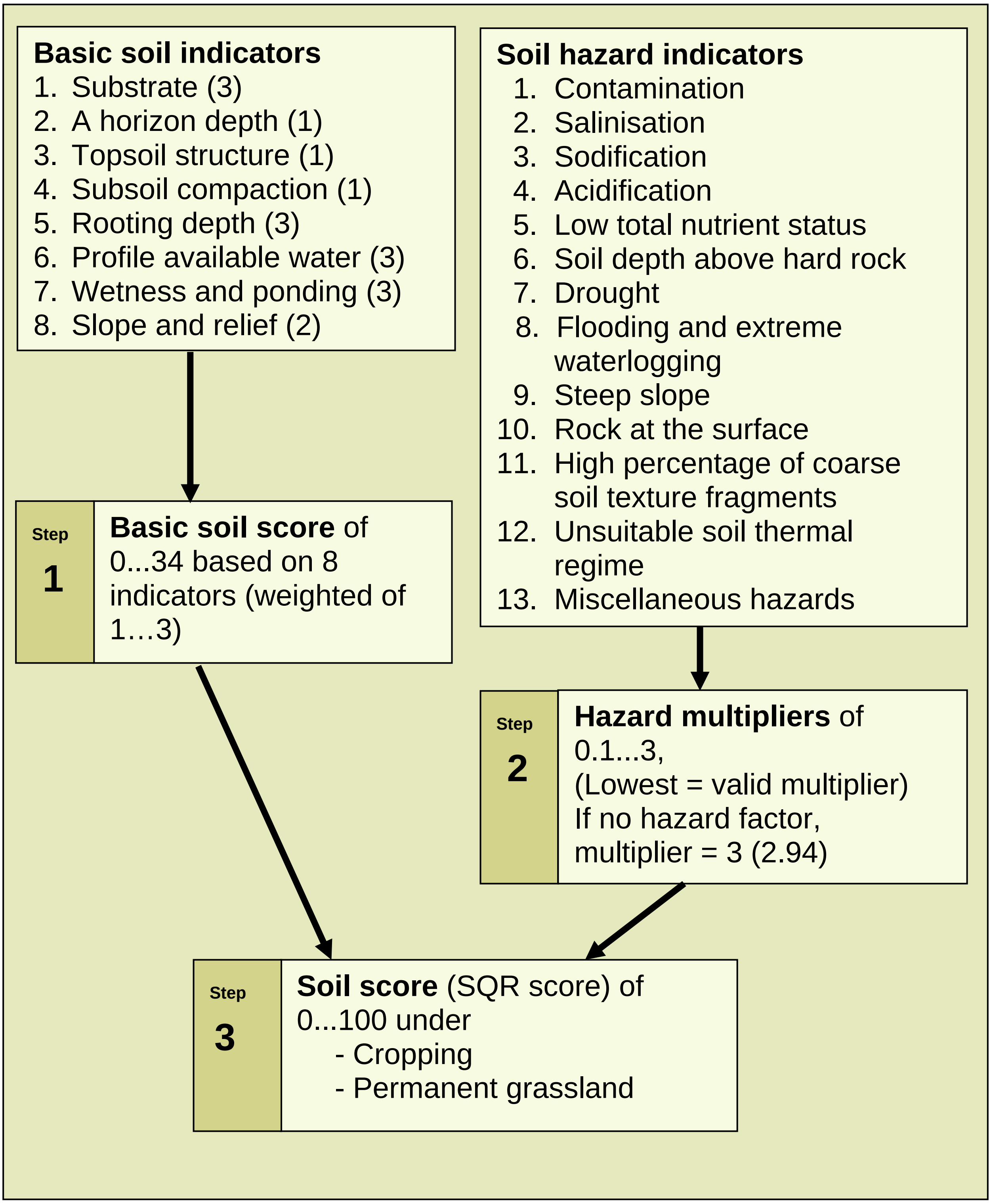


**Fig. 2.-1: Scheme of the Muencheberg SQR**

In SQR, hazard indicators are considered as multipliers for the basic soil score, ranging from about 0.01 (hazard properties do not allow farming) and 3 (no hazard properties). The lowest multiplier will be the valid one. The occurrence of more than one sub-optimum hazard indicators can be considered in such a way that the multiplier is set to a lower value within the range of scoring. In case of low ratings (< 1.5) of the slope gradient with sub-optimum (ratings < 2) of any further hazard indicator of Fig. 2.-1, the valid multiplier should be ranked into one score class lower than the minimum single lowest hazard indicator.
The rating system yields in a final score (SQR-score) ranging from about 0 to 100.
Classes of SQ are < 20 = Very poor, 20 - 40 = Poor, 40 - 60 = Moderate, 60 - 80 Good, > 80 = Very good.
Pedon ratings are transferable to landscapes.
The Muencheberg SQR of farmland considers both direct soil properties like profile available water and the influence of other factors of soil directly influenced by climate like the soil thermal regime, flooding and drought risk or influenced by relief. As the final rating score is depending not only on the soil pedon, but also on topography and climate, the subject of rating could be commonly called “site” or “land”. Agricultural use of soils in a landscape can never be separated from these soil forming factors affecting soil quality permanently. Many authors consider soil quality as a subset of land quality (Singer and Ewing, 2000). We decided to prefer the term **soil** and consider the terms “soil”, “earth”, “ground”, “site” and “land” as synonyms in the context of this paper.
The land used by mankind for one of their basic needs, food production, is soil, a living natural body. Knowledge about the value of soil and recognising degradation risks may help to develop conservation strategies worldwide.

## 3. Procedure and scoring tables

### 3.1. Field procedure

Communication with the owner or manager of the land and having all permissions required for digging a soilpit or boring a hole is the basic precondition for fieldwork.
The field procedure requires a minimum of equipment. This consists of:

- Spade + borer + foot rule + knife + this field guide

Additionally some equipment can be useful to detect soil properties of particular interest and for documentation of the work. These are:

- A probe for pH (or pH test strips) and electrical conductivity if acidification, sodification or salinisation is being expected
- A photo camera and GPS for referencing the data
- A stable plastic box, a larger plastic bag and the field guide “Visual Soil Assessment” (Shepherd, 2000) to perform VSA analysis

In the field, the exact sampling point should be determined by using available information from soil maps, airborne data and current or former vegetation pattern.

**Fig 3.1.-1: Before performing field tests, having permits and checking the ground for hidden dangers like cables or mines is important.**

**Fig 3.1.-2: Vegetation patterns are useful for pedon mapping and selection of representative sampling points.**
**Extreme variability of the soil quality over a few meters is typical of Holocene and Pleistocene soil landscapes in Central Europe. Differences are mainly due to layering of the soil substrate. Coarse and medium sand in the subsoil prevents rooting and has a low water capacity. Location Sophienthal, Germany.**

A small soilpit of about 20*30 cm and 40 cm deep will be dug using a common spade. It is recommended to perform the SQR jointly with the VSA method acc. to Shepherd, 2000 to gather more information on the status of the topsoil structure.
To recognise the soil layering or a shallow watertable, an auger of about 7 cm diameter will be drilled from the bottom of the pit down to a depth of 1.6 m. If the soil is expected to be relatively uniform with depth and to have no shallow watertable, a rill soil probe pushed in (Bohrstock) will be an adequate alternative.
The method requires some experience in estimating soil texture class and organic matter content. Variation of soil texture and humus with depth (layering) is a main parameter of interest.

**Fig 3.1.-3: Digging a small soilpit and performing the VSA drop scatter test according to Shepherd, 2000, gives information on texture and structure of the topsoil**

**Fig 3.1.-4: From the bottom of the soilpit a hole will be bored to detect soil layering and a shallow watertable.**

**Fig 3.1.-5: Examination of soil layering by a rill soil probe.**

## 3.2. Scoring of basic indicators

### 3.2.0. What are basic indicators?

Basic indicators of Table 3.2.0.-1 characterise important aspects of soil quality for cropping or grazing. They are primarily based on properties and layering of the soil substrate, e. g. texture and soil organic matter (SOM). SQ of current farmland in the temperate zone can be described by those indicators. Most farmland in this zone is prime farmland. Basic soil indicators range only in certain limits, and a single indicator will not prevent farming in most cases. Thus their combination to a total basic SQR score is empirically additive. This kind of rating is completely compatible to the VSA method which is focussing on management induced SQ, mainly soil structure (Shepherd, 2000).
The total SQR basic score as a weighted sum of eight indicators is quite well correlated with the crop yield within a particular region of the temperate zone, for example in the region of Berlin, Germany (Mueller et al., 2005). The depth of the potential rooting zone and the available water within this zone are crucial parameters of soil quality in this sub-humid region.
Basic indicators are recognizable by the look on a soil profile and can be assessed with the aid of scoring tables below. As this kind of data is "soft", the number of indicators has been set to eight. This makes the result of rating robust more than the use of a single indicator like the water capacity of the potential rooting zone (in: AG Boden, 2005).

**Table 3.2.0.-1: Basic indicators of the SQR method**

| | **Arable Land [1)]** | **Grassland** |
|---|---|---|
| 1 | Soil substrate (3) | Soil substrate (3) |
| 2 | A horizon depth (1) | Depth of humic soil (2) |
| 3 | Topsoil structure (1) | Topsoil structure (1) |
| 4 | Subsoil compaction (1) | Subsoil compaction (1) |
| 5 | Rooting depth (3) | Biological activity (2) |
| 6 | Profile available water (3) | Profile available water (3) |
| 7 | Wetness and ponding (3) | Wetness and ponding (3) |
| 8 | Slope and relief (2) | Slope and relief (2) |

[1)] The terms arable land and cropping land are used synonymously. Values in parentheses represent the weighting factor

Important criteria or further information for basic soil rating are as follows:

**Soil substrate**

- Soil texture class over the upper 80 cm (cropping land) or 50 cm
- Parent material of soil
- Strong gradients of texture within the upper 80 cm (layering)
- Content of coarse material > 2 mm over the upper 80 cm or 50 cm
- SOM of topsoil (upper 20 cm)
- Proportion of Carbonate, Gypsum, other concretions or artefacts

**Depth of A- horizon and depth of humic soil**

- A-horizon depth
- Depth of SOM content > 4 %
- Abrupt change from topsoil to subsoil

**Aggregates and porosity**

- Type and size of aggregates
- Structure ratings of Peerlkamp, Diez, Shepherd-VSA or others

**Subsoil compaction**

- Increased soil strength or density at 30-50 cm depth
- Redoximorphic feature in the topsoil and upper subsoil
- Structure ratings of Peerlkamp or others

**Rooting depth and depth of biological activity**

- Occurrence of roots
- Barriers to rooting and their intensity
- Effective rooting depth
- Zustandsstufe Bodenschaetzung

**Profile available water**

- Depth of watertable
- Water storage capacity of soil
- Grassland “Wasserstufe” (dry branch)

**Wetness and ponding**

- Depth of ground or perched water table
- Soil drainage class
- Degree of redoximorphic features in the subsoil
- Indicator values of vegetation
- Grassland “Wasserstufe” (wet branch)
- Soil position in a depression
- Wetness by suspended water (soils rich in silt and clay or muck)
- Ponding during soil assessment

**Slope and relief**

- Slope at the pedon position
- Microrelief and slope aspect at the pedon position

Single basic indicators will be described below.

**A note on scoring tables of basic indicators:**
Tables contain a score based on a description. To support scoring, prefixed explanatory text, some example photographs and orientation guides in the same or additional tables are given. This all shall support description but can never override it. Orientation guides come from different sources and do not necessarily match between different columns.

### 3.2.1. Soil substrate

Soil substrate, particularly that of the topsoil, largely controls all function of a soil. Soils of different texture may be advantageous for growing plants. Best soils for farming worldwide originate from loess. These soils are commonly deep, well drained and water storing. They have a large capacity to store nutrients because of their high cation-exchange capacity (CEC). Other soils like humic fine sands are very favourable for smallholder organic farming or for gardening. If soil depth is artificially restricted, for example in pot gardening, completely organic soil substrates are preferred.
Examples of unsuitable soils are those from coarse sand with low organic matter. They have a low storage capacity and tend to excessive leaching.
In the temperate zone of Western and Central Europe, in most soils of appropriate substrate the fertility status is not in a critical range due to a longer cultivation history in compliance with rules of crop rotation and nutrient cycling. This holds for the soil reaction and the content of stones largely too. Organic matter content is also correlated with the content of fine soil particles. For a given type of land use and climate, SOM is largely controlled by texture.
However, in dry regions, undesired components of soil substrate may occur. For example, high concentrations of calcium-sulphate or -carbonate (> 10 %) affect plant nutrition. In clayey soils they restrict root growth of most agricultural plants.
The dominant soil texture over the upper 80 cm (arable land) and 50 cm (grassland) will be scored by Table 3.2.1.-1.

**Fig. 3.2.1.-1: Soil substrate from Loess and a well developed A horizon with a not too sharp boundary to the subsoil are features of high soil quality.**
**However, Loess of this soil is underlain by coarse material at 0.7 m, limiting the substrate score to a sub-optimum of 1.5. Rooting depth and water capacity of the rootzone in a sub-humid climate are also limited. Vermi-calcic Chernozem, location Voderady, Slovakia (Surina, 2001).**

**Fig. 3.2.1.-2: Soil substrate from Loess (substrate score at optimum of 2). However, climate is humid and soil has stagnant properties giving reason for artificial drainage. Stagnic Luvisol, location Ostinghausen, Germany.**

**Table 3.2.1.-1: Scoring of basic indicator 1: Soil substrate**

| Score | Characteristics [1, 2] | Orientation guides | | |
|---|---|---|---|---|
| | | **Texture classes and parent material of the German soil rating system (In: AG Boden, 2005, p. 318)** | **Texture classes of AG Boden, 2005, p. 142** | **Texture classes of FAO/USDA (Guidelines, 1990, 2006)** |
| **2** | Loess, sandy loam, loam, optimum organic matter (SOM), all soils of SOM 8-20 %, free of coarse material (> 2 mm) | L-Loe, sL-Loe, SL-Loe, L-Al, L-V | lu, su, tu, sl, ll | silt loam, silt, loam, silty clay loam |
| **1.5** | Sandy loam, loam or loess of low SOM (< 2 % ), sandy soils of SOM 4-8 %, lowland clay, peat of fens, coarse material < 5 % | L-D, sL-D, sL-Al, sL-V, SL-D, SL-Al, SL-V, lS-Loe, L-Vg, LT-Al, LT-V, T-Al | ut, tl | sandy loam, sandy clay loam, sandy clay, clay loam, sandy clay, |
| **1** | Sand and loamy sand, clay of low SOM, better soils with higher prop. of coarse material (5-10 %), dense clays, peat of bogs | lS-D, lS-Al, lS-V, sL-Vg, SL-Vg, LT-D, LT-Vg, T-D, T-V | ls, us, lt (exc. Tt) | loamy sand |
| **0.5** | Medium to fine textured sands, low to medium SOM, coarse material > 10 %, very stony clays, natural peatsoils without mucky topsoil | Sl-D, Sl-Al, Sl-V, lS-Vg, T-Vg | fS, fSms, Tt | sand, clay |
| **0** | Coarse to medium textured sands, coarse material > 30 % | S-D, S-Al | Ss (exc. fS and fSms) | coarse sand |

[1] Presence of a significant textural gradient with depth above 0.8 m leads to a reduction by 0.5, possible maximum of score = 1.5

[2] If soil substrate is clearly chemically, biologically or physically degraded (for example contaminated or salinised), maximum score should be 0.5

Fig. 3.2.1.-3: Extreme stoniness in the soil profile (substrate score 0, drastic reduction of water capacity, score 0) Hyperskeletic Regosol. Location in Canterbury, New Zealand

Fig. 3.2.1.-4: Sandy soil of a coastal dune rangeland, substrate score 0.5. The iron bank (Ortstein) indicates extremely high leaching potential of the soil above. Location in Florianopolis, Brazil

### 3.2.2. Depth of A horizon and depth of humic soil

A well developed deep A-horizon is crucial for establishment of crops. It is an aspect of the long-term cultivation status. A-horizon contains the very most organic matter of the soil profile. This SOM plays a central role in maintaining key soil functions. It provides the binding and buffering capacity of soil and is an essential determinant of soil fertility. Intensive mechanisation of agriculture during the past decades has led to deep A-horizons of most soils in Western and Central Europe. Limitations with depth and SOM content and consecutive yield losses occurred mainly by water or tillage erosion (Den Biggelaar et al, 2003). Reduced topsoil thickness may limit crop yields (Al-Kaisi, 2001).
In grassland (including rangeland) a deep humic layer is also advantageous like in arable land. Most grasslands of the humid temperate zone in Europe have a long cultivation history and have been converted from forest or re-converted from arable land. Thus the depth of the Aw-horizon is not a reliable indicator of soil quality. Instead of Aw depth the depth will be used as an indicator at which SOM will fall below a threshold.

**Table 3.2.2.-1: Scoring of basic indicator 2, arable land: A horizon depth**

| Score | Depth | Remarks | Orientation guide degree of erosion acc. to AG Boden, 2005, p. 316 |
|---|---|---|---|
| 2 | > 25 cm | If sharp border to lower horizon or the A horizon is diluted by subsoil, 0.5 score less<br>If A horizon has very low SOM (< 2 %) or has gleyic or stagnic properties, 0.5 score less, and maximum score = 1 | Eg0,1 |
| 1.5 | 20 - 25 cm | | Eg2 |
| 1 | 15 - 20 cm | | Eg3 |
| 0.5 | 10 - 15 cm | | Eg4 |
| 0 | < 10 cm | | Eg5 |

**Table 3.2.2.-2: Scoring of basic indicator 2, grassland: Depth of humic soil ($d_h$)**

| Score | Characteristic | Remarks |
|---|---|---|
| 2 | $d_h$ > 0.6 m | Minimum SOM content of h = 4 %,<br>if h < 4 %, d = depth of rooting zone or horizon, and maximum score = 1 |
| 1.5 | $d_h$ 0.3 - 0.6 m | |
| 1 | $d_h$ 0.15 - 0.3 m | |
| 0.5 | $d_h$ 0.05 - 0.15 m | |
| 0 | $d_h$ < 0.05 m | |

### 3.2.3. Topsoil structure

Soil structure is important for many soil properties like water and air flow, water storage, biotic activity and workability (Kay and Angers, 2000). The topsoil structure has to provide germination of seeds and employment of water and nutrients by the plants. Friable, porous topsoils provide suitable conditions for plant roots and soil fauna. They retain the moisture necessary for microbial activity and nutrient cycling. Fine aggregates, extensive porosity and presence of earthworms and intensive rooting are indicators of a good structure. Wormcasts and holes as well as birds behind tillage are further positive indirect indicators of a good structure. Soil structure is mainly influenced by soil management and can be assessed by VSA (Shepherd, 2000) or similar methods.

Structure is also related to soil substrate, e.g. texture and SOM, and changes with structure may be very persistent.

Large sharp-edged or platy aggregates, clods or massiveness are examples of poor structure. In grassland, some species of vegetation indicate insufficient topsoil structure due to compaction. Shell-shaped aggregates indicate former excessive stock trampling.

**Table 3.2.3.-1: Scoring of basic indicator 3: Topsoil structure**

| Score | Characteristics | Orientation guides | | |
|---|---|---|---|---|
| | | **Porosity score of VSA method (Shepherd, 2000)** | **Structure score acc. to Diez and Weigelt, 1997** | **Peerlkamp note (Peerlkamp, 1967)** |
| **2** | Optimum aggregates and porosity, good rooted and aerated, many biopores, no sharp-edged aggregates | 2 | 1, 2 | => 7 |
| **1.5** | Between 2 and 1 | 1.5 | 2, 3 | 6 |
| **1** | Markedly disturbed aggregate hierarchy, coarse sharp-edged blocky aggregates of clay soils, or platy aggregates, none or a few biopores, no mottles in topsoils | 1, 0.5 | 3, 4 | 5 |
| **0.5** | Like above, but mottling or anaerobic feature below grassland, no or few earthworm burrows or worms | 0, 0.5 | 4 | 4 |
| **0** | Massive, no aggregation or extremely large aggregates of hard platy structure, no or extremely hampered root penetration | 0 | 5 | =< 3 |

Note: If single grain structure is dominant, maximum score =1.

**Fig. 3.2.3.-1: The arrangement of aggregates after performing the drop-shatter test of the VSA procedure (Shepherd, 2000) indicates differences of soil structure. The Manawatu soil (NZ: Weathered Fluvic recent soil, FAO WRB: Eutric Fluvisol) shows moderate to good structure conditions (score 1.5) whilst the very clayey Kairanga soil (NZ: Typic Orthic Gley, FAO WRB: Eutric Gleysol) has a high proportion of large blocky aggregates (score 0). Performance of the VSA procedure is recommended in conjunction with the Muencheberg SQR.**

**Fig. 3.2.3.-2: At sub-optimum soil structure roots use interfaces of aggregates. Location: Oderbruch region, Germany**

### 3.2.4. Subsoil compaction

Subsoil compaction occurs when soil is subject to deep mechanical pressure mainly through the use of heavy machinery. Soil compaction is potentially a major threat to agricultural productivity. It affects main aspects of soil quality adversely like restricting root growth, water storage capacity, fertility, biological activity and stability. Subsoil compaction is persistent as natural alleviation processes such as wetting/drying, freezing/thawing and biological activity including root growth decrease with depth. Wheel loads are still increasing and, in consequence, the extent and severity of subsoil compaction will increase too.

Compacted subsoil structure can also be a result of natural physical and chemical processes. High preconsolidation by former glaciation of the land or poor subsoil structure of sodic or dispersive clay are examples.

In cohesive soils sharp-edged large aggregates without any hierarchy are a sign of damaged subsoil.

In grassland, commonly the subsoil begins shallower. On meadows, machinery acts compacting. On pastures deep trampling in wet soil (pugging) can lead to unsuitable soil structure below the grassland. This is frequently combined with hydromorphic features of the subsoil and topsoil above. Sometimes in grassland reconverted from arable land, former subsoil compaction can be evident.

Table 3.2.4.-1 is valid both for arable land and grassland. Table 3.2.4.-2 is a supplement for grassland if unfavourable subsoil structure is combined with redoximorphic feature.

**Table 3.2.4.-1 : Scoring of basic indicator 4: Subsoil compaction**

| Score | Characteristics | Orientation guides | | | | |
|---|---|---|---|---|---|---|
| | | Tillage pan score of VSA[1)] | Structure score of Diez and Weigelt, 1997 | Peerlkamp note | Packing density acc. to Harrach et al., 1999 | Increase of soil mechanical resistance [2)] |
| **2** | No compaction, no sharp-edged aggregates | 2 | 1, 2 | => 7 | < 2 | Only slight |
| **1.5** | Slightly compacted, between 2 and 1 | 1.5 | 2, 3 | 6 | < 2 | Slight to moderate |
| **1** | Moderately compacted, few sharp-edged aggregates, disturbed aggregate hierarchy, biopores | 1.5 | 3, 4 | 5 | 2 - 3 | Moderate |
| **0.5** | Compacted, sharp-edged aggregates, few vertical macropores | 0, 0.5 | 4 | 4 | 3 - 4 | Distinct |
| **0** | Clearly compacted, large sharp-edged aggregates of hard structure, none or very few macropores | 0 | 5 | =< 3 | > 4 | Very distinct |

[1)] If depth of tillage pan > 20 cm
[2)] Knife test or penetration resistance at comparable substrate and moisture status, below tillage layer related to topsoil and/or deeper subsoil
[3)] Field assessment and/or estimate: PD = (DBD - 1.199 - 0.00204 sand) $0.1202^{-1}$

**Table 3.2.4.-2: Orientation guide of basic indicator 4, subsoil compaction, particularly under grassland**

| Score | Hydromorphic feature below grassland | Orientation guide |
|---|---|---|
| **2** | No redoximorphic feature[1)] in the upper 30 cm | See sample photographs of VSA (Shepherd, 2000, p. 63) |
| **1.5** | Up to 10 % oximorphic feature | |
| **1** | Up to 20 % oximorphic feature, but only a few features of reduction | |
| **0.5** | Redoximorphic feature > 20 %, also above 15 cm | |
| **0** | Strong redoximorphic feature, > 50 %, reduction zones | |

[1)] Includes oximorphic and reductomorphic features, oximorphic: mottles or concretions, reductomorphic: grey, blue, green or black coloured

**Fig. 3.2.4.-1: Hydromorphic feature and coarse aggregates below meadow grassland prone to wetness and compaction (score = 0). Soil is a Gleyic Fluvisol (Arenic) Location: Oderbruch region, Germany**

### 3.2.5. Rooting depth and depth of biological activity

A deep rooting system guaranties stable supply of crop water and nutrient requirements. It also minimises the risk of nutrient loss. Potential rooting depth limitation can be management-induced (compaction, water table control) but is often due to natural soil layering. Soils that are deep and have desirable texture and no structure limitations are suitable for most plants. Deep soils contain more plant nutrients and water than shallow soils. Shallow, stony, impervious soils, on the other hand, hold little nutrients and water. Crop yield is clearly correlated with soil rooting depth (Timlin et al., 2001, Sadras and Calvino, 2001), however, this effect can be compensated by irrigation (Timlin et al., 2001) or by climate. In many soils the rooting depth is restricted by physical or chemical barriers. Soil physical characteristics known to influence root development are penetration resistance, aeration, water retention, sharp contrasts in soil properties including fragipans and other compact horizons, cemented layers, lithic or paralithic contacts. Examples of extreme physical barriers are rock, a cemented hardpan, or particularly dense massive clay subsoil. A perched or permanent water table can also act as a barrier to root development. Changes in soil bulk density or mechanical soil resistance due to either compaction or naturally-occurring textural horizons, can significantly affect rooting depth. In terms of soil classification, root-limiting layers may be fragipans, duripans; petrocalcic, petrogypsic, and placic horizons; ortstein, and densic, lithic, paralithic, and petroferric contacts (Pedosphere.com., 2001).
A very low pH of about 4.5 or less presents a chemical barrier to root growth. Medium and coarse textured sand may act as physical, chemical and biological barrier to rooting. Cone penetrometer resistance of more than 2 MPa inhibits root growth (Taylor and Gardner, 1963). Some soil types like Rendsinas, Rankers, or Lithic or Petroferric phase or soils in permafrost regions, have a limited potential rooting depth. Rooting depth is determined by both crop and soil properties. Inhibition of root development may also occur in early stages of crop establishment due to sealing of the soil surface.

**Fig. 3.2.5.-1: A dense cemented layer of calcium carbonate can limit rooting depth for cropping (score 0.5). Soil is a Limnic Fluvisol (Calcaric, Drainic). Location Baerwinkel, Germany.**

Under grassland, rooting depth is not a reliable soil quality indicator as shallow roots of grass cannot use the rooting potential of many soils. Deep digging organisms like anecic earthworms indicate the potential of soil to reclaim the resource of deeper soil.
As earthworms, especially deep burrowing species avoid hydromorphic zones (Cannavacciuolo et al., 1998) both wormholes and hydromorphic zones seem to be suitable indicators of biological activity and deep rooting potential.

**Fig. 3.2.5.-2: Haplic Luvisol from Pliocene parent material. The dark brown Bt horizon has clayey texture and stagnant properties in spring, limiting root development of cereals. Location Lovech, Bulgaria, (Penkov and Mueller, 2001).**

**Table 3.2.5.-1: Scoring of basic indicator 5, arable land: Rooting depth (RD)**

| Score | Characteristic | Barriers [1) 2)] to rooting |
|---|---|---|
| **2** | RD > 1.5 m | Water table, anoxic layers, SOM free sandy layers > 0.2 m, coarse SOM free sands > 0.1 m, rock or gravel underground, iron pans, compacted layers > 0.3 m, strongly acid, sodic or saline layers, permanently dry subsoil |
| **1.5** | RD 1.1 - 1.5 m | |
| **1** | RD 0.8 - 1.1 m, maximum of sandy soils | |
| **0.5** | RD 0.5 - 0.8 m | |
| **0** | RD < 0.5 m | |

[1)] If barriers to seedling emergence exist like soil tending to surface crusting, water repellency or hardsetting, reduction by 0.5
[2)] Rooting depth must be estimated based on visible roots or effective rooting depth. Barriers give an orientation to potential rooting depth (which is a maximum of current observed rooting depth or of potential rooting depth) if they are absolute barriers like uncracked hardrock. Intensity of most barriers may be very different.

**Table 3.2.5.-2: Orientation guide of rooting depth (RD)**

| Score | Effective rooting depth AG Boden, 2005, p. 356, 1) | Zustandsstufe German soil rating, in: AG Boden, 2005, p. 318 | Classes of root-restricting depth (Soil Survey Manual, Chapter Three) 2) | |
|---|---|---|---|---|
| **2** | > 1.3 m | 1 - 2 | Very deep | > 150 cm |
| **1.5** | 1 - 1.3 m | 3 | Deep | 100-150 cm |
| **1** | 0.8 - 1 m | 4 | Moderately deep | 50-100 cm |
| **0.5** | 0.5 - 0.8 m | 5 | Moderately deep | 50-100 cm |
| **0** | < 0.5 m | 6 - 7 | Shallow and very shallow | > 50 cm |

1) assuming field capacity moisture status at the begin of the vegetation period

2) http://soils.usda.gov/technical/manual/contents/chapter3e.html#54

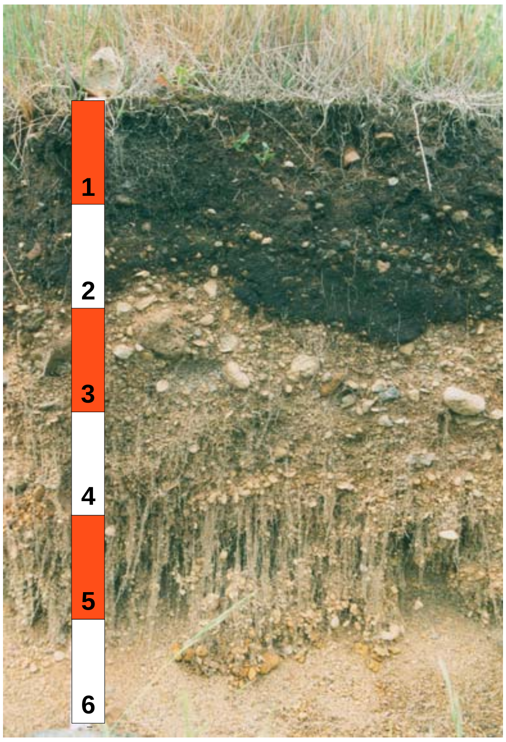


**Fig. 3.2.5.-3: Soil from volcanic ash (Pumice soil) of extreme low density. Even roots of grass can penetrate this soil down to 0.6 m. Score of biological activity = 2. Location in Taupo region, New Zealand**

**Fig. 3.2.5.-4: Coarse or medium textured sandy subsoil is a barrier to rooting. Farmers tried to increase rooting depth by deep ploughing. Current rooting depth of cereals is about 0.7 m, rating score 0.5. Soil is a Gleyic Fluvisol (Anthric, Eutric, Arenic, Drainic).**
**Location Sydowswiese, Oderbruch region, Germany.**

**Table 3.2.5.-3 : Scoring of basic indicator 5, grassland: Biological activity**

| Score | Characteristics |
|---|---|
| **2** | Indication of active bioporosity > 30 cm, mole activity or potential [1)], worm holes or worms of deep burrowing species like *Lumbricus terrestris*, numerous other species of soil fauna, intensive deep rooting of grasses > 60 cm |
| **1.5** | Active bioporosity > 20 cm, worm holes or worms of medium to deep digging species, numerous other species of soil macrofauna, rooting of grasses 40-60 cm |
| **1** | No indication of macrofauna or biogene pores deeper than 15 cm, moderate rooting of grasses ( 30-40 cm) |
| **0.5** | No indication of macrofauna or biogene pores deeper than 10 cm, restricted rooting of grasses (< 30 cm) |
| **0** | No indication of macrofauna or biogene pores deeper than 5 cm , extremely restricted rooting of grasses (< 20 cm) |

[1)] e. g. moles or similarly living animals in the neighbourhood or at similar soil conditions at the same field

### 3.2.6. Profile available water

Profile Available Water (PAW) is the water capacity of a soil profile available for vegetation. PAW equals the water storage, commonly estimated as the difference in water content between field capacity and wilting point within the effective soil rooting depth. In case of a shallow watertable, this resource of potential groundwater consumption will be added according to the rules of the AG Boden, 2005. Stone content within the potential root zone diminishes the calculated value.
PAW is a crucial parameter of soil quality, in particular in regions of rain deficit during the vegetation period. It can buffer the effect of insufficient rainfall. Reliable estimation of this indicator is difficult as the stored amount of water at the beginning of the vegetation period can vary. This is mainly dependent on climate. In drier regions, many soils have high water storage capacity but this resource is not available as the store is not filled.
Estimates of Table 3.2.6.-1 are based on a filled store at the beginning of the vegetation period. This can be assumed for the temperate humid climate.
Local adaptions of field capacity related to the climate and the infiltration and depletion processes of different soils should be considered (Schindler et al., 2004). For example, the suction at field capacity could be varied between pF 1.8 (udic local field moisture regime, humid or per-humid climate), pF 2 (sub-humid climate) and pF 3 (aridic local field moisture regime).
On grassland, vegetation indicates the medium-term soil moisture status. Moisture numbers less than 4 of the Ellenberg scale (Ellenberg et al., 2001) or “Grasland-Wasserstufen” less than -2 are indicators of an ecologically dry soil moisture status.

**Table 3.2.6.-1: Scoring of basic indicator 6: Profile available water**

| Score | Characteristics | Orientation guides | |
|---|---|---|---|
| | | PAW in the effective rooting depth of AG Boden, 2005 [1)] | Grassland "Wasserstufe" (in AG Boden, 2005, p. 319/320) |
| **2** | No deficit of PAW, high water storage capacity of soil substrate (Loess, silty loam) or optimum or shallow water table | > 220 mm | 1- (minus) or higher |
| **1.5** | Slight water deficit due to sub-optimum storage capacity, rooting depth or water table | 160-220 mm | 2- |
| **1** | Distinct water deficit | 100-160 mm | 3- |
| **0.5** | Strong water deficit, sandy soils and deep water table | 60-100 mm | 4- |
| **0** | Extreme water deficit, coarse sands or very shallow rooting depth | < 60 mm | 5- |

[1)] The orientation guide of Table 3.2.6.-1 refers to temperate humid conditions assuming the soil profile saturated to field capacity at the beginning of the vegetation period. It is related to differences in suction between -10 and -1500 kPa.
If the climate is sub-humid (P < 500 mm/yr) and the water table deeper than 1.2 m and the substrate score 1 or greater, 50 mm more are required to reach the same score. This is due to sometimes insufficient recovery of the soil water store during winter.

### 3.2.7. Wetness and ponding

Wetness and ponding (waterlogging) occurs when the soil profile is saturated with water or water appears above the soil and plants lack air. The severity of waterlogging depends on climatic, geomorphological and pedological site properties. Depressions and lowlands are more prone to waterlogging than higher land. The permeability of the soil, depth to water table and plant water use have an influence on the degree of waterlogging. Soils in per-humid regions and soils of impeded internal drainage are also subject to wetness and ponding. High and perched water tables limit the soil aeration status and root development of crops. Ponding reduces the topsoil nutrient status markedly. If the soil is cohesive, numerous days with topsoil water content higher than the plastic limit may delay soil management (technological wetness).
Rust-coloured mottles indicate wetness, but this is not a reliable criterion as the feature may be relictic. A soil profile with dominantly reductomorphic feature (grey, black, blue or green colours) at shallow depth indicates prolonged saturation with water. The water table commonly occupies this zone permanently.
Grasses and wetland plants are more tolerant to waterlogging than arable crops. On grassland, hydrophytic plants are reliable indicators of wetness.

**Fig. 3.2.7.-1: Longer ponding on arable land is not tolerable for crops like winter wheat and causes soil compaction and management problems.**
**Location: Oderbruch region, Germany**

**Table 3.2.7.-1: Scoring of basic indicator 7: Wetness and ponding [1)]**

| Score | Characteristics | Remarks |
|---|---|---|
| **2** | No surface ponding or wetness | If soil position is in a depression, maximum score = 1.5, if soil suffers from wetness by suspended water (soils rich in silt and clay or muck), maximum score = 1.5 |
| **1.5** | Surface ponding extremely rare, temporal wetness in the rootzone can occur for shorter periods | |
| **1** | Moderate surface ponding up to 3 days after heavy rainfall possible | |
| **0.5** | Significant wetness in the rootzone for longer periods, moderate ponding | |
| **0** | Significant surface ponding and wetness in the rootzone can occur for longer than 3 days after heavy rainfall | |

**Table 3.2.7.-2: Orientation guide of wetness and ponding**

| Score | **Soil drainage class acc. to Soil Survey Manual, chapter three** (USDA/NRCS, 2005) | **Depth of ground or perched water table m [1)]** | **Degree of redoximorphic features in the subsoil, AG Boden, 2005, p. 315 [2)]** | **Indicator values of vegetation [3)]** | **Grassland "Wasser-stufe" (in AG Boden, 2005, p. 319/320)** |
|---|---|---|---|---|---|
| **2** | Well, Somewhat excessively, Excessively | > 1 | Vn0 | => V, mF < 5.5 | 1+ (or lower) |
| **1.5** | Moderately well | 0.8 - 1 | Vn1 | mF 5.5-6.5 | 2+ |
| **1** | Somewhat poorly | 0.6 - 0.8 | Vn2 | IV, mF 5.5-6.5 | 3+ |
| **0.5** | Poorly | 0.5 - 0.8 | Vn3-4 | | 3+ to 4+ |
| **0** | Very poorly | < 0.5 | Vn5-6 | >= III, mF > 7 | 4+ to 5+ |

1) Temperate humid and sub-humid zones, if drainage is impeded by soil structure or indications of additional perched water, or clear technological wetness, 0.5 score less.
2) Without consideration of wet humus accumulation, neglecting relictic oxymorphic feature
3) Ecological degree of wetness acc. to AG Boden, 2005, p. 360-361, mF = mean wetness number of vegetation acc. to Ellenberg et al., 2001 on grassland

**Fig. 3.2.7.-2: Rushes (*Juncus spec.*) are indicators of a poor aerated soil due to compaction and /or wetness. Location: Pohangina, Manawatu, New Zealand.**

### 3.2.8. Slope and relief

Slope is a morphologic feature of the landscape and has a significant influence on soil formation, soil management and risk of degradation. Soils with slope gradients greater than 4 percent have risks of higher runoff and soil erosion and require management practices that protect the soil surface and minimise runoff. Worldwide, erosion is the most severe threat of sloped soils. On slopes of less than 7 % common agricultural machinery is applicable (Webb and Wilson, 1995).

Almost flat slopes are best suitable for cropping. Worldwide, in cases of high demand of farmland, very steep slopes (more than 30 %) are commonly used as grassland or even as arable land (Sun et al., 2006). However, the erosion risk is then very high.
Slope aspects and relief position are also important factors of soil quality. Their function is largely climate-dependent. In warm and dry climates on the Northern Hemisphere, southern aspects are more prone to drought, failure of crops and damage by erosion. In cool climates, northern aspects are indicated by late thawing and delay in the development of vegetation.

Slope is associated with soil types to a certain degree. For example, Fluvisols, Gleysols, Histosols, Planosols, Solonchaks, Solonetz and Vertisols are lowland soils (gradient < 8 %). Regosols, Rendsinas, Cambisols, Acrisols, and Nitosols are soils of sloping areas (gradient 8 - 30 %), and Andosols, Rankers and Lithosols are often associated with steep slopes (Fischer et al., 2002).

**Table 3.2.8.-1: Scoring of basic indicator 8: Slope and relief [1)]**

| Score | Slope gradient characteristic | Gradient arable land | Gradient grassland | Orientation guide Inclination acc. to AG Boden, 2005, p. 58 |
|---|---|---|---|---|
| **2** | No to very weak | < 2 % | < 4 % | N0 |
| **1.5** | Weak | 2 - 4 % | 4 - 9 % | N1 |
| **1** | Weak to moderate | 4 - 9 % | 9 - 14 % | N2 |
| **0.5** | Moderate | 9 - 12 % | 14 - 30 % | N3.1 |
| **0** | Distinct to steep | > 12 % | > 30 % | => N3.2 |

[1)] Within the given score range of 0 to 2, a modification by 0.5 (one class) can be taken into account due to microrelief and slope aspect

**Table 3.2.8.-2: Orientation guide for scoring slope gradient on the basis of soil description acc. to Guidelines, 2006, Table 7, p. 12**

| Slope gradient class | Slope gradient Percent | Orientation guide of rating scores | |
|---|---|---|---|
| | | Arable land | Grassland |
| < 05 | < 2 (Flat to very gently sloping) | 2 | 2 |
| 05 | 2 - 5 (Gently sloping) | 2 | 2 |
| 06 | 5 - 10 (Sloping) | 1 | 1.5 |
| 07 | 10 - 15 (Strongly sloping) | 0.5 | 1 |
| 08 | 15 - 30 (Moderately steep) | 0 | 0.5 |
| > 08 | > 30 (Steep and very steep) | 0 | 0 |

**Fig. 3.2.8.-1: Distinctly sloped part within a field grown with winter rye. Slope is associated with loss of the A-horizon by water and tillage erosion. Soil is a Hypoluvic Arenosol (Dystric). Location: Libbenichen, vicinity of Berlin, Germany**

## 3.3. Scoring of hazard indicators

### 3.3.0. What are hazard indicators?

Hazard indicators characterise hazard properties of soils. Hazard properties of soils are capable of completely to superimpose other properties and to limit the quality of the total soil profile. For example, if a soil is too shallow or contaminated, no cropping will be possible. Some of the basic properties described above have this potential if their indicators reach extreme values. In this conception hazard properties, if occurring have been considered as multipliers and will clearly downgrade the total soil score. Multipliers in the tables below will provide a certain frame for scoring, depending on the risk of occurrence and the severity of the problem, e. g. possibilities and costs of soil rehabilitation, or dependent on climate.
Reliable scoring of hazard properties may require measurements in some cases. For example, if common indicators like vegetation are not enough sensitive to score acidification or sodification or salinisation, a field test kit for measuring pH and the electric conductivity may be very helpful.

**Table 3.3.0.-1: Checklist of Hazard Indicators and thresholds for orientation**

| **Indicator** | **Thresholds for orientation** | | |
|---|---|---|---|
| | **Direct soil parameters** | **Indirect parameters of vegetation** [2]**, climate or others** | **Soil reference groups (SRG) or *qualifiers* of WRB** [1] |
| **1.** Contamination | Specific for each pollutant acc. to international thresholds | High risk areas: cities, waste affected soils, floodplains | *Toxic, (Garbic, Spolic)* |
| **2.** Salinisation | EC > 2 mS/cm in topsoil | White crusts on soil surface, occurrence of halophytes, S-number acc. to Ellenberg > 3 | *Salic, Hypersalic, Puffic, Chloridic* |
| **3.** Sodification | ESP > 15 % (SAR > 13), pH > 8.2 in topsoil | High pH indicating plants, R-number acc. to Ellenberg of 9 | *Sodic, Alcalic, Natric* |
| **4.** Acidification | pH < 5.2 (cropping) or 4.5 (grassland) in topsoil | Low pH indicating plants, R-number acc. to Ellenberg of 3 or lower | *Hyperdystric, Hyperthionic* |
| **5.** Low total nutrient status | Clear deficit of nutrients, cannot be compensated by fertilisation within one year | | *Hypergypsic, Hypercalcic* |
| **6.** Soil depth above hard rock | Hardrock or permafrost < 120 cm (arable land) or < 70 cm (grassland) | | *Leptic, Lithic, Petric* |
| **7.** Drought | Water budget in the main vegetation period < 500 mm, ustic, xeric or aridic soil water regime, | Climatic water balance in the main vegetation period of 4 months < -100 mm, probability of the occurrence of a dry month > 10 %, aridity index acc. to De Martonne < 30, benefit of irrigation for cereals | *Aridic* |
| **8.** Flooding and extreme waterlogging | Flooding probability > 5 %, aquic or peraquic soil water regime | Delay of beginning of farming on cropping land > 20 d, Grassland mF (Ellenberg) > 8, clear benefit of land drainage | *Floatic, Gelistagnic, Subaquic, Tidalic* |
| **9.** Steep slope | Arable land gradient > 12 %, grassland gradient > 30 % | | |
| **10.** Rock at the surface | Arable land > 0.01 % rock outcrop, grassland > 0.05 % | | Leptosols; *Ekranic, Hyperskeletic* |

| | | | |
|---|---|---|---|
| **11.** High percentage of coarse soil texture fragments | Arable land > 15 % by mass of coarse fragments (> 2 mm) in topsoil, grassland > 30 % | | Leptosols; *Hyperskeletic, Skeletic* |
| **12.** Unsuitable soil thermal regime | Frigid, cryic or pergelic soil thermal regime | Tundra regions Duration of the frost free period < 140 d | Cryosols; *Cryic, Glacic* |

1) SRG or qualifiers not in brackets are clear hazard indicators
2) See examples of vegetation indicator species of drought, wetness, acidity, sodicity and salinity of Central Europe in Appendix 3. Region-specific values should be preferred if available (for example Bui and Henderson, 2003, Victorian Resources online. 2007. ELLENBERG'S INDICATOR VALUES FOR BRITISH PLANTS, 2007).

**A note on scoring tables of hazard indicators:**
Tables contain a score based on a description and thresholds if available. To support scoring, prefixed explanatory text, some example photographs and orientation guides in the same or additional tables are given. This information shall support the description but can never override it. Orientation guides come from different sources and do not necessarily match.
Based on the scores, a range of multipliers for the basic score is indicated. Within the given range of multipliers, an expert based individual adjustment of the multiplier will be possible.

### 3.3.1. Contamination

Commonly, agriculturally used soils are relatively clean. However, due to chemical or nuclear hazards or enhanced soil quality standards, content of detrimental substances can exceed thresholds. This means loss of soil quality and a risk for food quality. Many contaminated soils are relictic. Soil contamination can result in the damage of several soil functions and the contamination of surface water and groundwater. It belongs to the hot spots of soil degradation in Europe (EEA, 2000).
To detect and quantify contamination requires special analyses. However, pressure indicators like knowledge of frequent sewage sludge application or the location of the field in the vicinity of an industrial emitter can give first information on the risk. Artificial soils (Urban soils, Technosols acc. to WRB, 2006) show high risk of being contaminated. Besides that, most intensively human-induced and managed soils e. g. garden-like soils within or in the vicinity of big cities or bottomland soils of polluted rivers are prone to contamination.
A sensory analysis of the soil substrate on the basis of common criteria like kind of artefacts, colour and odour (Lichtfuss, 2004) of soil may provide important hints for contamination of soils.

**Fig. 3.3.1.-1: Soils developed on debris or urban waste have a high risk of being contaminated. Soil is an Urbic Technosol (Reductic, Arenic). Location Buenos Aires, Argentina.**

**Table 3.3.1.-1: Scoring of contamination**

| Score | Characteristic | Multiplier |
|---|---|---|
| **2** | No contamination | 3 |
| **1.5** | Slight exceedance of thresholds, no risk for food safety | 1.5 - 3 |
| **1** | Slight exceedance of thresholds, minimum risk for food safety | 1 - 1.5 |
| **0.5** | Distinct exceedance of thresholds | 0.5 - 1 |
| **0** | Extreme exceedance of thresholds | 0.01 - 0.5 |

### 3.3.2. Salinisation

Saline soils contain higher amounts of soluble salts that interfere with the growth of most plants. The physiological functions of the total plant, in particular the roots will be damaged (Vaughan et al., 2002). Salinisation is a typical problem of soils in drier regions with irrigation and may become more important in the currently temperate zone because of climate change. Even in the humid temperate zone salinisation may occur as a local phenomenon due to upward transport of water and diluted salts. Solonchaks are a type of soils having a salic horizon starting within 50 cm from the soil surface.
If strong salinisation is manifested in soils, high efforts will be required of leaching the salts by irrigation and drainage. If not controlled, salinisation will result in completely unproductive soils. The electrical conductivity of the saturation extract is a proper measure of salinisation.

**Fig. 3.3.2.-1: Devastated soil by salinisation after long-term subsoil- irrigation in a semi-arid environment.**
**Location in Victoria, Australia**

**Table 3.3.2.-1: Scoring of salinisation** (in relation to Withers et al., 1978, p. 91 and Abrol et al., 1988, Soil Survey Manual, 1993 (USDA/NRCS, 2005), Kotuby-Amacher, et al., 1997, Department of Agriculture, Western Australia, 2005)

| Score | Characteristics | Electric conductivity EC [1)] | Multiplier arable land | Multiplier grassland |
|---|---|---|---|---|
| **2** | No salinisation, no injury on all plants. | < 2 | 3 | 3 |
| **1.5** | Low salinisation, sensitive plants and seedlings of others may show injury | 2 - 4 | 1.5 - 3 | 2.6 - 3 |
| **1** | Moderate salinisation, yields of most non-salt tolerant plants will be restricted, salt-sensitive plants will show severe injury | 4 - 8 | 1 - 1.5 | 2 - 2.6 |
| **0.5** | Strong salinisation, salt-tolerant plants will grow, most others show severe restrictions | 8 - 16 | 0.5 - 1 | 1.5 - 2 |
| **0** | Extreme salinisation, only very tolerant plants and halophytes will grow, salt crusts at the surface | > 16 | < 0.5 | < 1.5 |

[1)] Saturation extract of topsoil (mmho $cm^{-1}$ = mS $cm^{-1}$ = dS $m^{-1}$), if EC is measured in 1:5 solution, conversion is necessary according to Guidelines, 2006

### 3.3.3. Sodification

In the temperate zone, sodification is a phenomenon of drier regions due to the geological and climatic situation or irrigation with sodic water.

Sodicity is due to a high percentage of exchangeable sodium (ESP) of the total cation exchange capacity of the soil. This leads to soil dispersion, associated with clogging up the soil pores, reducing water and air permeability, limiting of root growth and slowing of drainage. The soil is more difficult to cultivate. Surface soil crusting, subsoil waterlogging, low nutrient efficiency and accelerated water erosion are consecutive problems of sodicity.

Sodicity is associated with alkalinity. In a certain range of alkalinity, micronutrients such as iron, zinc, copper, manganese and boron, but also macronutrients like phosphorus and potassium, are less available for plant use. Sodification and salinisation may occur in combination.

Solonetz is a type of soil having a natric horizon within 100 cm from the soil surface. An ESP of more than 15 percent or a sodium adsorption ratio (SAR) value of 13 are considered the threshold value for a soil classified as sodic (Abrol et al., 1988). This means that sodium occupies more than 15 percent of the cation exchange capacity (CEC).

In the field, a soil pH above 8.4 indicates a sodium problem. Sodic soils of high clay content show a typical columnar soil structure.

**Fig. 3.3.3.-1: Coarse columnar structure of a Solonetz. Grassland vegetation is adapted to low to moderate sodification, score 1.5, multiplier 2.8. Location at Neusiedler See, Austria (Nelhiebel et al., 2001).**

**Table 3.3.3.-1: Scoring of sodification (related to Abrol et al., 1988)**

| Score | Characteristics | ESP[1)] | pH | Multiplier arable land | Multiplier grassland |
|---|---|---|---|---|---|
| **2** | No to slight sodification, very sensitive crops may be slightly adversely affected | < 15 | < 8.2 | 3 | 3 |
| **1.5** | Low to moderate sodification | 15 - 30 | 8.2 - 8.4 | 2.5 - 3 | 2.7 - 2.9 |
| **1** | Moderate to high sodification | 30 - 50 | 8.4 - 8.6 | 2 - 2.5 | 2.5 - 2.7 |
| **0.5** | High to very high sodification | 50 - 70 | 8.6 - 8.8 | 1 - 2 | 2 - 2.5 |
| **0** | Extreme sodification, plant growth is adversely affected, only extremely tolerant native grasses may grow | > 70 | > 8.8 | < 1 | < 2 |

[1)] Saturation extract of topsoil

### 3.3.4. Acidification

Acid soils naturally occur in humid climates through processes of leaching and acid deposition. Soil acidity can vary according to geology, clay mineralogy, soil texture and buffering capacity. Acidification is a major land degradation issue (Bolan et al., 2003). Agricultural management like use of physiological acid fertilisers and nitrogen leaching can greatly accelerate the rate of acidification. When soil becomes more acidic the basic cations (Ca, Mg) are replaced by hydrogen ions or solubilised metals. The basic cations can be leached, and soils become less fertile and more acidic. Commonly, plant and crop growth are limited because of a reduction in the availability of nutrients (calcium, magnesium, boron, phosphorous, molybdenum and potassium) and/or an increase in toxic levels of aluminium, iron or manganese. Many plants can tolerate only small quantities of these elements before the soil becomes toxic and restricts plant growth. Acidity is measured by determining the pH of a soil. A result below pH 5.5 in water indicates growth limitations of acid-sensitive plants like some alfalfa, barley and canola. Acidification can properly be mitigated by liming.

**Table 3.3.4.-1: Scoring of acidification (related to AG Boden, 2005, p. 367)**

| Score | Characteristics | pH [1)] | Multiplier arable land | Multiplier grassland |
|---|---|---|---|---|
| **2** | No significant acidification | > 5.2 | 3 | 3 |
| **1.5** | Low to moderate acidification, sensitive crops may be adversely affected | 4.5 - 5.2 | 2.5 - 3 | 3 |
| **1** | Moderate to high acidification | 4 - 4.5 | 2.2 - 2.5 | 2.7 - 3 |
| **0.5** | High to very high acidification | 3.3 - 4 | 2 - 2.2 | 2.5 - 2.7 |
| **0** | Extreme acidification, plant growth is adversely affected, only extremely tolerant native grasses may grow | < 3.3 | < 2 | < 2.5 |

[1)] in 1:5 soil (air dried) : water extract

**Fig. 3.3.4.-1: Rangeland consisting of *Corynephorus canescens* and lichens vegetation on an acid sandy soil (Umbric Podzol, pH 4, acidification score 0.5-1, multiplier 2.7), Location: Garnischberg, Oderbruch region, Germany**

### 3.3.5. Low total nutrient status

Mainly due to climatic conditions and parent material, some soils may have an extreme low nutrient status. Also some soils which do not clearly meet criteria of salinisation/sodification or other hazards, may have an extremely low nutrient status. For example, de-salinised soils may maintain their low nutrient status for a long time. Low nutrient status will only act as a hazard indicator as common fertilisation will not counterveil against the soil nutrient deficiency.

**Table 3.3.5.-1: Scoring of the soil nutrient status**

| Score | Characteristics | Multiplier arable land | Multiplier grassland |
|---|---|---|---|
| **2** | No lack of nutrients, or slight deficits can be compensated by single fertilisation | 3 | 3 |
| **1.5** | Moderate deficit of some nutrients, shortfall of soil-specific recommendation values | 2.5 - 3 | 2.8 - 3 |
| **1** | Clear deficit of some nutrients, compensation only by ameliorative fertilisation | 2 - 2.5 | 2.5 - 2.8 |
| **0.5** | Clear deficit of most nutrients, compensation possible over several years only | 1.5 - 2 | 2.2 - 2.5 |
| **0** | Extreme deficit of nutrients, high risk for food security, deficits can only be compensated by high doses of fertilisation over several years or not at all | 1 - 1.5 | 2 - 2.2 |

### 3.3.6. Soil depth above hard rock

Hard rock or permanently frozen soil are extreme barriers to rooting and cannot be modified by common human cultivation activity. This is in contrast with the barriers described by the basic indicators above.
In terms of soil typology, Rankers or Rendsinas above rock or many Gelisols, e. g. soils with permafrost belong to soils having hazard of soil depth limitation. Hard rock at shallow depth seriously influences not only the root zone of plants, but also soil management.
Multipliers should be primarily adapted to the soil moisture regime and thus to climate. Applying higher values in case of humid climate and lower values in case of arid climate is recommended. In case of a per-humid climate or a humid climate of very even distribution of rain over the vegetation period, upgrading by 0.5 score is possible. In case of hardrock having clear cracks and fissures preventing stagnant water, upgrading by 0.5 is also possible.

**Table 3.3.6.-1: Scoring of soil depth above hard rock [1, 2)]**

| Score | Characteristic | Multiplier [2)] arable land | Multiplier [2)] grassland |
|---|---|---|---|
| **2** | No depth limitations by hard rock[1)] within 120 cm | 3 | 3 |
| **1.5** | Hard rock in 120-60 cm | 2 - 3 | 2.7 - 3 |
| **1** | Hard rock in 30-60 cm | 0.5 - 2 | 1 - 2.7 |
| **0.5** | Hard rock in 10-30 cm | 0.1 - 0.5 | 0.5 - 1 |
| **0** | Hard rock < 10 cm | < 0.1 | < 0.5 |

[1)] Permafrost can also be considered as hard rock
[2)] Consequent adjustment of multipliers (within the indicated range) to climate is recommended: Higher multipliers at deeper soil and perhumid/humid climate, lower multipliers at shallower soils and semiarid/arid climate

### 3.3.7. Drought

Lack of water for plants is the most severe limitation of soils for cropping and grazing worldwide (Hillel and Rosenzweig, 2002). Drylands cover more than 50 % of the global land surface (Asner and Heidebrecht, 2005). Negative impacts of global warming on crop yield are expected also for currently productive cropping areas (Lobell and Asner, 2003). There is also evidence of climatic change leading to serious drought in grassland ecosystems (WMO, 2004).
Reduction in precipitation over an extended period of time affects the soil moisture regime. Other climatic factors (such as high temperatures and low relative humidity) can increase the severity.
Drought is difficult to define. Sometimes it will be considered as a temporary aberration only, in contrast to aridity, which is described as a permanent feature of climate. However in a high precipitation area, a reduction of rain will not induce soil water deficits to the plant cover. Thus, agricultural drought should include aridity as a special case.
As drought influences plant growth via the soil water regime, effects of drought often accumulate slowly over a certain period of time.
For any particular site, the drought risk is depending on the probability of occurrence and the level of severity of deficit precipitation, as well as the profile available water (water supply in the effective rooting depth of AG Boden, 2005, see Table 3.2.6.-1). As a consequence of drought, affected soils are classified as suitable for irrigation. Thus, on the other hand, available classifications of irrigation benefit can be used as orientation guides of drought severity.
Within a climatic region, an unbalanced soil water budget over the vegetation period can be used as a measure of drought (Schindler et al., 2006). It is a sum of the profile available water of soil, the effective rainfall and the irrigation water within the vegetation period.
If the soil is not irrigated, climatic indices of drought including aridity have to be taken into consideration.
Examples of simple climatic indices are the Climatic water balance (AG Boden, 2005, p. 374) or the aridity index of UNEP (In: Rivas-Martínez, 2004). As the estimation of the potential evapotranspiration can lead to very different results in dependence on the method applied, diverse older indexes based on temperature and precipitation like the factors of Lang, de Martonne, Bagnouls/Gaussen or Emberger (In: Rivas-Martínez, 2004) also seem to be acceptable. Though these indices are very similar, classification results however may differ. For example, the climate in the region of Berlin, Germany (P = 550 mm, T = 9 °C) can fall into the following groups of classification:

Lang: Temperate warm to semiarid
De Martonne: Subhumid to humid
Emberger: Humid
Bagnouls/Gaussen: Axeric cold to axeric temperate
UNEP: Humid

Rating of drought is a very sensitive item of the SQR. Therefore, in Tables 3.3.7.-2 to 4, different orientation guides are given.

Note: Drought can also be rated 1.5 or less in case of PAW ratings of 2. Loess soil in a sub- humid or semi-arid climate (Chernozems, for example) may have 220-250 mm of PAW (optimum score of 2), but a drought risk score of 1.5.


**Fig. 3.3.7.-1: Soils prone to both flooding and drought are typical of many regions in semi-arid and arid zones.**
**Location in Queensland, Australia**

Long-term soil water regime and vegetation provide also potential indicators of drought, like the Grassland “Wasserstufe” of the German soil rating system (in AG Boden, 2005, p. 319). Wasserstufe values of 4- and 5- or Ellenberg values less than 4 indicate dry soils in Central Europe. If the climate is between humid and sub-humid conditions (many landscapes east of the Elbe river in Central Europe) and the profile available water (see basic indicator 6) is lower than 120 mm, a certain drought risk of score 1.5 can be expected.

**Table 3.3.7.-1: Scoring of drought risk**

| Score | Characteristic | Multiplier arable land | Multiplier grassland |
|---|---|---|---|
| **2** | No risk of drought | 3 | 3 |
| **1.5** | Low risk of drought | 2.5 - 3 | 2 - 3 |
| **1** | Medium risk of drought | 1 - 2.5 | 1 - 2 |
| **0.5** | High risk of drought | 0.1 - 1 | 0.5 - 1 |
| **0** | Extreme high risk of drought | < 0.1 | < 0.5 |

**Table 3.3.7.-2: Orientation guide of drought risk**

| Score | Water budget mm [1] | Climatic water balance in the main vegetation period of 4 months [2,3] | Benefit of irrigation | Water regime classes of Soil Survey Manual [4] |
|---|---|---|---|---|
| **2** | > 500 | > -100 | None to low | Udic (or wetter) |
| **1.5** | 350 - 500 | -100… -200 | Moderate | Ustic |
| **1** | 200 - 350 | -200… -300 | High | Xeric |
| **0.5** | 100 - 200 | -300… -500 | Very high | Aridic |
| **0** | < 100 | < -500 | Extremely high | Aridic |

[1] During the main vegetation period of 4 months, WB = Effective Precipitation (sum of daily P > 2 mm) plus PAW (storage capacity plus groundwater supply) plus irrigation
[2] Precipitation minus FAO-PM Grass reference ET (Allen et al., 1998)
[3] Climatic criteria of Table 3.3.7.-3 give orientation for rain-fed cropping and zonal soils, not for soils under irrigation and not for soils influenced by groundwater. In case of irrigation the actual water budget and its risk of deficiency have to be taken into consideration.
[4] USDA/NRCS, 2005

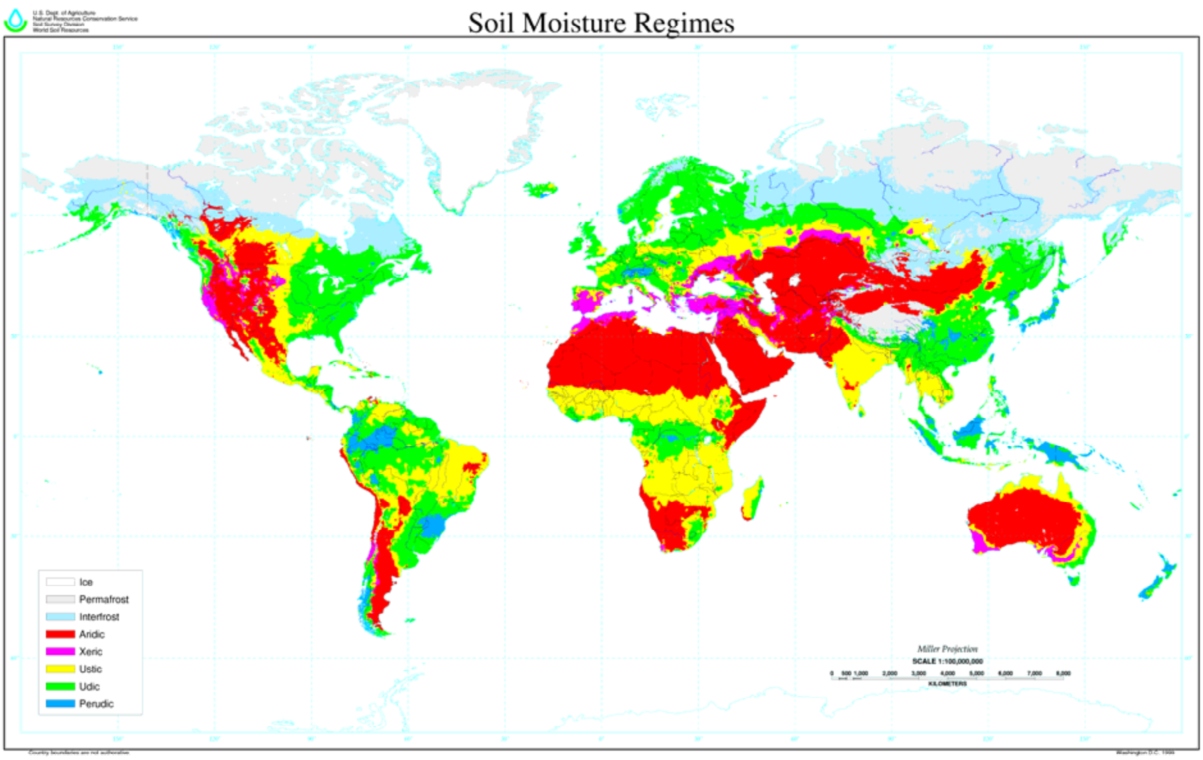


**Fig. 3.3.7.-2 Global orientation of soil moisture regime classes,** map adopted from USDA/NRCS (2007)

**Table 3.3.7.-3: Orientation guide of drought risk, continuing [1)]**

| Score | Probability of the occurrence of a dry month [2)] | Aridity index acc. to De Martonne [3)] | Bailey moisture index [4)] | Ombrothermic index Io [5)] of Rivas-Martínez, 1997 |
|---|---|---|---|---|
| **2** | < 10 % | > 30 (humid) | > 8.7 (humid and perhumid) | >7 (humid and hyperhumid) |
| **1.5** | 10 - 20 % | 20 - 30 (subhumid) | 6.4-8 (moist subhumid) | 3.6-7 (subhumid) |
| **1** | > 20 % | 15 - 20 (semiarid) | 4.7-6.4 (dry subhumid) | 2-3.6 (dry) |
| **0.5** | > 20 % and more than 1 month | 5 - 15 (arid) | 2.5-4.7 (semi-arid) | 1-2 (semiarid) |
| **0** | > 50 % and more than 1 month | < 5 (extremely arid) | < 2.5 (arid) | < 1 (arid and hyperarid) |

1) Climatic criteria only for rain-fed cropping and zonal soils, not for soils under irrigation and not for soils influenced by groundwater

2) Dry month acc. to Bagnouls/Gaussen: $P < T/2$, where P = monthly sum of precipitation in mm and T = monthly mean temperature in °C, within the main vegetation period

3) $AI = [P/(T + 10) + 12\ p/(t + 10)]/2$, P = annual precipitation, T = mean annual temperature, p = precipitation of the driest month, t = temperature of the driest month

4) Bailey moisture index Si = Sum of months 1 to 12 (0.18 p/1.045**t), where p = monthly precipitation, t = monthly temperature in °C

5) Io = Pp * 10/Tp. The quotient resulting from the value of the yearly precipitation in mm of the months with average temperature higher than 0 ºC divided by the value, expressed in centigrade degrees resulting from the total of the monthly average temperatures higher than 0 ºC.

**Table 3.3.7.-4: Orientation guide of drought risk, continuing**

| Score | Main biomes |
|---|---|
| **2** | Tundra, Alpine, Boreal forest (Taiga), Temperate forest, Tropical rain forest |
| **1.5** | Temperate Grassland |
| **1** | Mediterranean, Chaparral, Savanna |
| **0.5** | Desert-scrub |
| **0** | Desert |

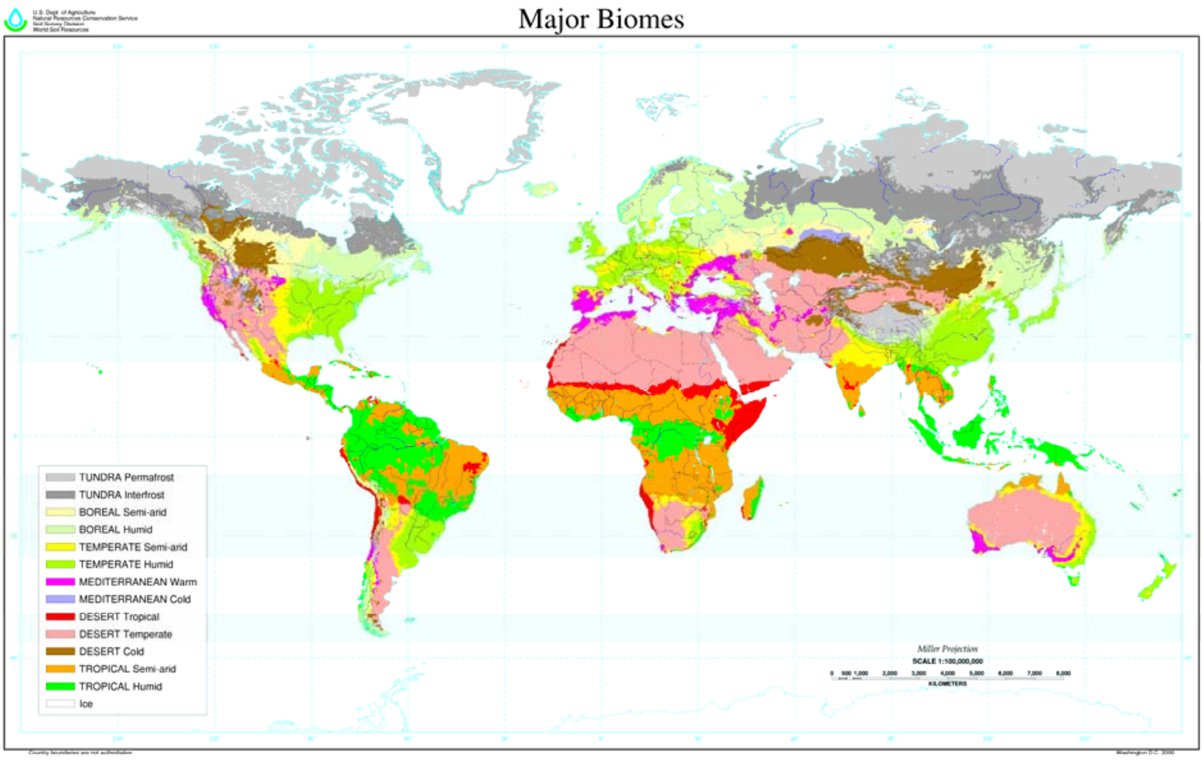


**Fig. 3.3.7.-3 Global orientation of biomes,** map adopted from USDA/NRCS (2007)

**Fig. 3.3.7.-4: Spatial variability of drought. Growing of cereals in a local depressional area by using surface recharge flow from adjacent hills. Recharge of > 100 mm/yr improves the water budget. Surrounding grassland without water surplus suffers from drought. „Brown soils" from Colluvium. Location near Pune, state of Maharashtra, India**

**Fig. 3.3.7.-5: In case of irrigation the current soil moisture regime due to irrigation management determines the soil water capacity and the drought risk. Additionally the SQ without irrigation should be scored. Location Niedergoersdorf, vicinity of Berlin, Germany. Soils are Haplic Luvisols and Eutric Cambisols, texture loamy sand. At this location sprinkler irrigation eliminates the slight drought risk completely; the basic water capacity score is at optimum of 2 and no more drought risk. As no further hazard occurs, the multiplier is at maximum of 3 (2.94). Without irrigation the basic score of water capacity is at sub-optimum of 1, the hazard score would be 1.5 and the multiplier would be lower, around 2.6. Total SQR-score of the soil is 80 with irrigation and 67 without irrigation.**

Another very rough orientation for scoring drought risk related to Koeppen climatic zones is given in the later section 3.3.12.

### 3.3.8. Flooding and extreme waterlogging

Susceptibility to flooding (including inundation and extreme wetness due to permanent high water tables or perched water) imposes a serious limitation to farming, especially to cropping. Assessment of potential frequency, severity and duration of flooding is difficult and requires long-term knowledge about the site. In Western and Central Europe most rivers have intact constructed levees and the risk of flooding is mainly restricted to the recent floodplain. The flooding risk depends on the relative height of the soil above the river level.
Outside of floodplains, due to moderate rainfall distribution in the temperate climate, the inundation risk of soils in the landscape is limited to some lowlands and depressions.
Risk assessment includes both the flooding probability and the possible severity/damage.
Soils in bottomlands and/or in high rainfall areas may suffer from extreme waterlogging, which can farming affect very adversely or make impossible. A clear benefit of land drainage is an indirect parameter of extreme waterlogging.
The following Tables 3.3.8.-1 to 4 provide a frame for scoring hazard by flooding or extreme waterlogging. In case of occurrence of combinations of extreme waterlogging with flooding risk, the lowest score or a score of a class deeper is possible.

**Table 3.3.8.-1 : Scoring of flooding hazard risk or extreme waterlogging [1)]**

| Score | Characteristics of flooding regime | Characteristics of extreme waterlogging | Multiplier arable land | Multiplier grassland |
|---|---|---|---|---|
| **2** | No or low risk of flooding (< 5 %) | Low or moderate level of waterlogging | 3 | 3 |
| **1.5** | Low risk of flooding (< 10 %) and/or short inundation (< 20 days) at the beginning of the vegetation period [2)] | Occurrence of surface water (ponding) for longer time in the vegetation period, Ground or perched water dominating the topsoil for more than 20 days in the vegetation period | 1 - 3 | 2.5 - 3 |
| **1** | Medium risk of flooding (10-20 %) and/or longer inundation (20--40 days) at the beginning of the vegetation period | Very long period of wetness, ground or perched water occupying the topsoil for more than 60 days in the vegetation period | 0.5 - 1 | 2 - 2.5 |
| **0.5** | High probability of flooding (20-50 %) and/or longer inundation (40-90 days) at the beginning of the vegetation period | Very long wetness period | < 0.5 | 1 - 2 |
| **0** | Extremely high probability of flooding (> 50 %) and/or longer inundation (> 90 days) at the beginning of the vegetation period | Extreme waterlogging, cropping impossible, only a short growing period for grassland | < 0.1 | < 1 |

[1)] Flooding and extreme waterlogging should be rated independently. If both occur, the lowest rating or a score one class deeper is recommended
[2)] If inundation occurs later in the vegetation period, inundation damage is higher and the allowable length for this score has to be cut in half for the next three months, for example: Vegetation period starts in March, and inundation is in March, than inundation of 20 days possible, if inundation is in April, only 10 days possible, if inundation is in May, only 5 days, June, July, August and September (end of main vegetation period) 2-3 days

**Fig. 3.3.8.-1: Flooded Grassland meadow soils; WRB: Gleyic Fluvisols (Arenic); along the Oder river, (flood hazard risk score 0.5, multiplier 1.5), Location: Oderbruch region, Germany**

**Table 3.3.8.-2: Orientation guide of scoring flooding risk**

| Score | Inundation frequency and duration (based on Soil Survey Manual, chapter three [1)]) | Examples in floodplain areas |
|---|---|---|
| **2** | None or rare (Less than 5 times in 100 years) and brief (less than 2 days) | Soils outside of levees or highlevel terraces |
| **1.5** | | Dune ridges, sand plains above general level of terrace plain |
| **1** | Occasional (5 to 50 time in 100 years) and long (1 week to 1 month) | Gullies, scoured drainage zones and prior stream channels within midlevel terraces |
| **0.5** | | Low terraces including drainage zones and shallow ridges |
| **0** | Frequent (> 50 times in 100 years) and very long (> 1 month) | Immediate river margins, very low terraces |

[1)] http://soils.usda.gov/technical/manual/contents/chapter3c.html#28

**Table 3.3.8.-3: Orientation guide of scoring extreme waterlogging**

| Score | Water regime classes of Soil Survey Manual | Benefit[1)] of land drainage |
|---|---|---|
| **2** | Udic or drier | None to low |
| **1.5** | Perudic | Moderate |
| **1** | Aquic | High |
| **0.5** | Peraquic | Very high |
| **0** | Peraquic | Extremely high |

[1)] Benefit in terms of crop yield increase and better soil management

**Table 3.3.8.-4: Orientation matrix of scoring extreme waterlogging by perched water (based on classes of the Soil Survey Manual, Chapter Three, Table 3-5) [1)]**

| Cumulative annual pattern / Depth | Very Shallow (SV) < 25 cm | Shallow (S) 25 to 50 cm | Moderately Deep (DM) 50 cm to 1 m | Deep (D) 1.0 to 1.5 m | Very Deep (DV) > 1.5 m |
|---|---|---|---|---|---|
| Absent (A) Not observed | 2 | 2 | 2 | 2 | 2 |
| Very Transitory (TV) Present <1 month | 1 | 1.5 | 2 | 2 | 2 |
| Common (C) Present 1 to 3 months | 1 | 1 | 1 | 1.5 | 2 |
| Transitory (T) Present 3 to 6 months | 0.5 | 0.5 | 1 | 1 | 2 |
| Persistent (PS) Present 6 to 12 months | 0 | 0.5 | 0.5 | 1 | 2 |
| Permanent (PM) Present Continuously | 0 | 0 | 0.5 | 1 | 2 |

[1)] http://soils.usda.gov/technical/manual/contents/chapter3c.html#28

### 3.3.9. Steep slope

Slope is a landscape property of particular importance for agricultural land use. Considering good agricultural practice, low to moderate gradient can provide farming without hazard to soil, whilst steep slopes can lead to the complete loss of soil by erosion or landslide. This possible hazard is being considered in the second rating of the slope.
Loss of soil due to erosion by water or tillage is a major problem associated with slope. Erosion hazards are caused by a combination of climate, vegetation cover and agricultural practices (EEA, 2000, Eswaran et al., 2001). The risk of water erosion was considered indirectly by slope gradient rating (section 3.2.8).

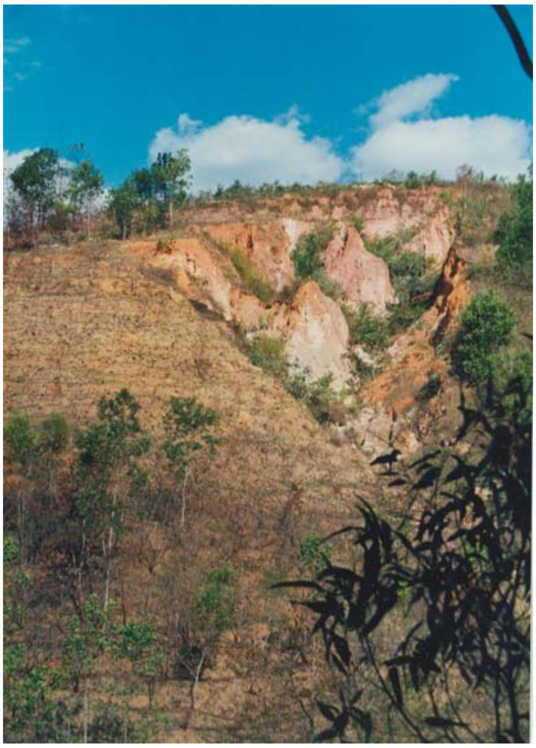

**Fig. 3.3.9.-1: Gully erosion on steep land in a tropical humid environment. Acrisol soil landscape,**
**Location Pinheiral, State of Rio de Janeiro, Brazil.**

**Fig. 3.3.9.-2: Farmland use of very steep slopes can lead to landslide (slip) erosion. Intact deep A-horizons at very different slope positions at this site show slip erosion appeared for the very first time since cultivation. Location: Pohangina, Manawatu, New Zealand.**

**Table 3.3.9.-1: Scoring of hazard from slope**

| Score | Arable land gradient % | Grassland gradient % | Multiplier |
|---|---|---|---|
| **2** | < 12 | < 30 | 3 |
| **1.5** | 12 - 18 | 30 - 40 | 2.5 - 3 |
| **1** | 18 - 27 | 40 - 50 | 2 - 2.5 |
| **0.5** | 27 - 36 | 50 - 60 | 1 - 2 |
| **0** | > 36 | > 60 | < 1 |

**Table 3.3.9.-2: Recommendation values of multipliers for slope gradient classes acc. to Guidelines, 2006, Table 7, p. 12**

| Slope gradient class | Description | Slope gradient Percent | Multiplier arable land | Multiplier grassland |
|---|---|---|---|---|
| < 07 | Sloping to flat | 5-10 | 3 | 3 |
| 07 | Strongly sloping | 10-15 | 2-3 | 3 |
| 08 | Moderately steep | 15-30 | 1-2 | 3 |
| 09 | Steep | 30-60 | < 1 | 1-3 |
| 10 | Very steep | > 60 | 0 | < 1 |

### 3.3.10. Rock at the Surface

Rock outcrops or stones and boulders at the surface create cultivation hazard. They hinder the agricultural use of soil for cropping in particular. The damage to pastoral grazing is much less.

**Table 3.3.10.-1: Scoring of stones and boulders at the surface** (related to Soil Survey Manual (USDA/NRCS, 2005) Chapter 3, Table 3-12**.**) [1)]

| Score | Characteristic | Percentage | Orientation guide of Soil Survey Manual [1)] | Multiplier arable land | Multiplier grassland |
|---|---|---|---|---|---|
| **2** | No stones or boulders at the surface | < 0.01 | | 3 | 3 |
| **1.5** | Low to moderate stony or bouldery | 0.01 - 0.1 | Class 1 | 2 - 3 | 2.8 - 3 |
| **1** | Very stony or very bouldery | 0.1 - 3.0 | Class 2 | 1 - 2 | 2 - 2.8 |
| **0.5** | Extremely stony or extremely bouldery | 3.0 - 15 | Class 3 | < 1 | 1.5 - 2 |
| **0** | Very rubbly | > 15 | Class 4 - 5 | < 0.5 | < 1.5 |

[1)] http://soils.usda.gov/technical/manual/contents/chapter3e.html#54

**Fig. 3.3.10.-1: Left part: Extremely shallow soils and rock at the surface. Score 0, multiplier grassland < 1.**
**Association of Nudilithic and Lithic Leptosols with Leptic and Colluvic Regosols,**
**Location near Pune, state of Maharashtra, India**

**Fig. 3.3.10.-2: Extremely high proportion of stones at the surface limits SQ for grassland use (score 0, multiplier < 1).**
**Hyperskeletic Leptosol.**
**Location in Canterbury, New Zealand.**

### 3.3.11. High percentage of coarse soil texture fragments (> 2 mm)

Coarse fragments limit the effective surface of soil particles and may diminish the storage of water and nutrients and the filtering and buffer function of soils. On cropping land, the total management may be hampered. Growing rootcrops may be difficult or impossible.
On the other hand, on very shallow soils, a certain proportion of coarse material may be advantagous to provide a minimum of rooting depth.

**Table 3.3.11.-1: Scoring of coarse soil texture fragments (> 2 mm)**

| Score | Characteristics | Orientation guide % by mass [1] | Multiplier arable land [2] | Multiplier grassland |
|---|---|---|---|---|
| **2** | Low percentage of coarse fragments | < 15 | 3 | 3 |
| **1.5** | Moderate | 15-40 | 2 - 3 | 2.5 - 3 |
| **1** | High proportion of coarse fragments | 40-60 | 1 - 2 | 2 - 2.5 |
| **0.5** | Very high proportion of coarse fragments | 60-85 | 0.5 - 1 | 1.5 - 2 |
| **0** | Extremely high proportion of coarse fragments, mainly angular shape and fraction > 63 mm | > 85 | < 0.5 | < 1.5 |

[1] Related to classes of AG Boden, 2005, Table 33, p. 150, values refer to the rooting zone
[2] Within a class, higher multipliers in case of smaller fractions, round aggregates and a more humid climate, and smaller multipliers if fraction is coarser, blocky or non-natural (e.g. construction waste), and climate is dry

### 3.3.12. Unsuitable soil thermal regime

The soil thermal regime is important for all physiological processes of plants. On grassland and rangeland, species were able to adapt to the thermal conditions. Cropping of annual plants requires critical minimum temperatures for all stages of development. Most grasses germinate at temperatures > 5 °C and many arable crops germinate and grow at temperatures > 10 °C. An upper limit of soil temperatures for adequate farming seems to exist with temperatures > 30 °C, exceeding this limit is thus detrimental for plant growth. High fluctuations of temperature in combination with other hazards which occur in semi-desert and desert regions are more important for the potential of soil for farming. Temperature recordings of the air thermal regime (e .g. climate data) are proper indicators of the soil thermal regime. The length of both the vegetation period and the frost free period are direct agro-climatic constraint for cropping, but also an indirect indicator of the soil thermal regime.
Modifications may be considerably determined by the snow cover in winter. Even under very harsh climate conditions snow can protect soils against deep freezing and provide acceptable conditions of cropping.

**Table 3.3.12.-1: Scoring of soil thermal regime** (related to Soil Survey Manual, USDA/NRCS, 2005, and Guidelines, 2006, p. 88-90.)

| Score | Characteristics | Multiplier arable land | Multiplier grassland |
|---|---|---|---|
| **2** | Suitable or moderate regime, frost free period > 140 days | 3 | 3 |
| **1.5** | Slightly too cold or too hot | 2.5- 3 | 3 |
| **1** | Too cold or too hot | 1-2.5 | 1.5-3 |
| **0.5** | Very cold, very short vegetation period or too hot | 0.5-1.5 | 1-1.5 |
| **0** | Extremely cold, permafrost or extremely hot | < 0.5 | < 1 |

**Table 3.3.12.-2: Orientation guide of multipliers for temperature regime classes of Soil Survey Manual**

| Soil moisture regime | Multiplier arable land | Multiplier grassland |
|---|---|---|
| Pergelic | < 1 | < 1.5 |
| Cryic | 1-2.5 | 1.5-3 |
| Frigid | 2.5-3 | 2.5-3 |
| Isofrigid | 2.5-3 | 3 |
| Mesic | 3 | 3 |
| Isomesic | 3 | 3 |
| Thermic | 3 | 3 |
| Isothermic | 3 | 3 |
| Hyperthermic | 3 | 3 |
| Isohyperthermic | 3 | 3 |

**Table 3.3.12.-3: Orientation guide of scores for the soil thermal regime**

| Score | Duration of frost-free period (days) [1)] | Main biomes | Mean annual temperature for grassland in the temperate climate, ° C [2)] |
|---|---|---|---|
| **2** | > 140 | Tropical rain forest, Temperate forest, Mediterranean, Savanna, Temperate Grassland | > 8 |
| **1.5** | | Forest steppe in Asia | < 8 |
| **1** | 90-140 | Boreal forest | < 5 |
| **0.5** | | | < 3 |
| **0** | < 90 | Tundra | < 1 |

[1)] Within the 6 warmest months (vegetation period)
[2)] Orientation for mountain regions within the temperate climate only

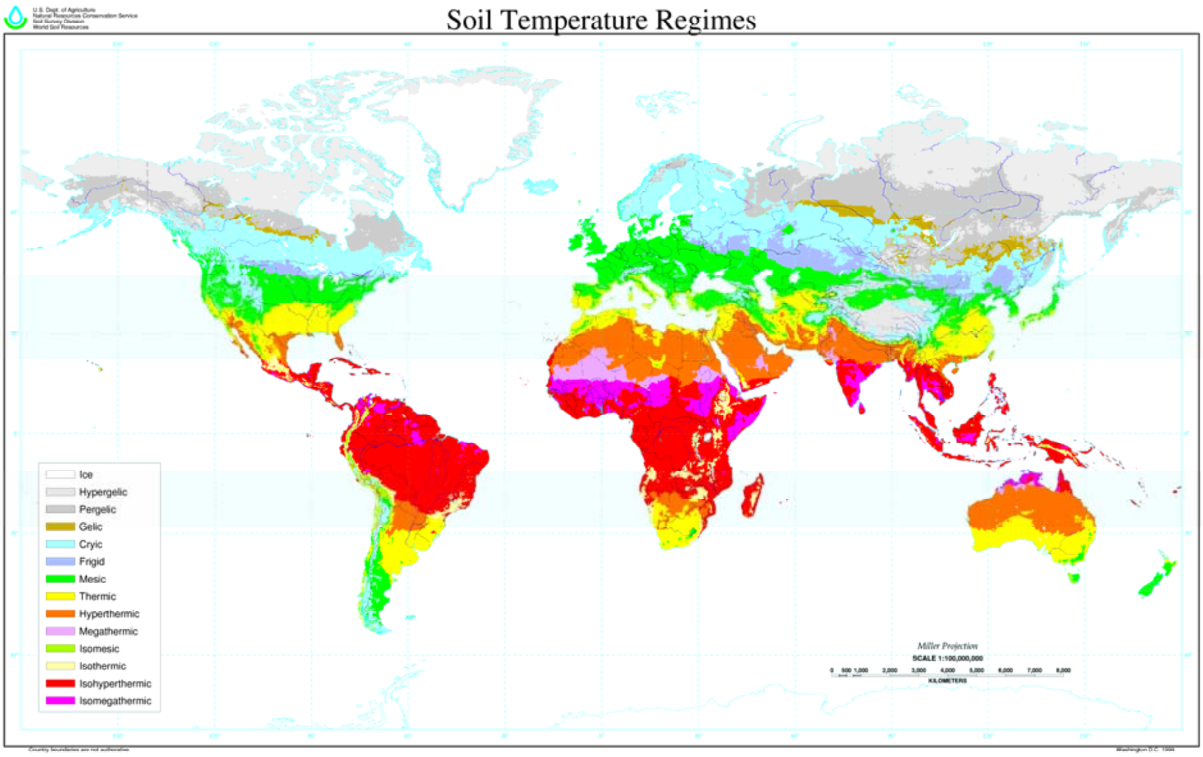


**Fig. 3.3.12.1: Global orientation of the soil thermal regime, map adopted from USDA/NRCS (2007)**

**Table 3.3.12.-4: Orientation guide of drought and soil thermal regime scores for Koeppen climatic zones[1)]**

| **Climatic zone** | | **Drought score** | | **Thermal regime score** | |
|---|---|---|---|---|---|
| | | **Arable land** | **Grass-land** | **Arable land** | **Grass-land** |
| **Tropical (Af)** (tropical wet) | | 2 | 2 | 2 | 2 |
| **Monsoon (Am)** (tropical monsoon) | | 1.5 | 1.5 | 2 | 2 |
| **Savanna** | **As** | 0.5 | 1 | 2 | 2 |
| | **Aw** | 1 | 1.5 | 2 | 2 |
| **Arid** | **BWh** (desert hot) | 0 | 0 | 1 | 1 |
| | **BWk** (desert cold) | 0 | 0 | 1 | 1 |
| **Semi-arid** | **BSh** Subtropical (warm) Steppe | 0 | 0.5 | 2 | 2 |
| | **BSk** Midlatitude (cool) Steppe | 0.5 | 1 | 1.5 | 1.5 |
| **Humid subtropical** | **Cfa** Humid Subtropical Year-Round Wet | 2 | 2 | 2 | 2 |
| | **Cwa** (moist, dry winters, long hot summer) Humid Subtropical Winter-Dry | 0.5 | 1 | 2 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| **Oceanic** | **Cfb** (maritime temperate moist all year, mild winters, long cool summers) | 2 | 2 | 2 | 2 |
| | **Cwb** | 1.5 | 1.5 | 2 | 2 |
| | **Cfc** subpolar oceanic (moist all year, mild winters, short cool summers) | 2 | 2 | 1.5 | 1.5 |
| **Mediterranean** | **Csa** (moist, mild winter, long hot dry summer) | 0.5 | 1 | 2 | 2 |
| | **Csb** (moist mild winters, long cool summers) | 1 | 1.5 | 2 | 2 |
| **Humid continental** | **Dfa** (moist all year, cold winters, long hot summers) | 1 | 1.5 | 1.5 | 1.5 |
| | **Dwa** Humid Continental Winter-Dry | 1.5 | 1.5 | 1.5 | 2 |
| | **Dfb** (moist all year, cold winters, long cool summers) | 2 | 2 | 1.5 | 1.5 |
| | **Dwb** | 1.5 | 2 | 1.5 | 2 |
| **Subarctic** | **Dfc** (moist all year, cold winters, short cool summers) | 2 | 2 | 0.5 | 1 |
| | **Dwc** | 1.5 | 2 | 1.5 | 2 |
| | **Dfd** | 2 | 2 | 0.5 | 1 |
| **High-altitude Mediterranean** | **Dsa** | 0.5 | 1 | 1.5 | 2 |
| | **Dsb** | 1 | 1.5 | 2 | 2 |
| | **Dsc** | 1.5 | 1.5 | 2 | 2 |
| **Subarctic Winter-Dry Dwd** | | 1 | 1.5 | 0.5 | 0.5 |
| **Polar** | **ET** (polar tundra) | 1.5 | 2 | 0 | 0 |
| | **EF** (polar icecap) | 1 | 1 | 0 | 0 |
| **Alpine (ETH)** | | 1.5 | 2 | 0 | 0.5 |

[1)] For global orientation see also the World Map of the Koeppen-Geiger climate classification by Kottek et al., 2006

### 3.3.13. Miscellaneous hazards

Examples of further hazards to soils and farming are: Subsidence of organic soils, streambank erosion, frost action and gypsum at the surface (Muckel, 2004). They may be also rated according to the common criteria of Table 3.3.13.-1. Another hazard, wind erosion is a big concern to human and environment. The occurrence is more related to soil management and rating is thus part of the VSA method (Shepherd, 2000) which is recommended to be performed in combination with the SQR method. In case of serious deflation of the soil or depositiony (dune formation with burying the current soil) this can be rated as a hazard acc. to Table 3.3.13.-1. A rule of thumb is that pure sandy soils (clay < 5%, silt < 10%) have a very high wind erosion risk if the annual average of windspeed at 10 above the ground is higher than 3 m/s. If soils are sandy-silty (clay < 8%, silt < 50%) the wind erosion risk is classified as very high at windspeeds > 5 m/s (Deutsche Norm, DIN 19706, 2004).

Also, common soil erosion by water can be scored if the slope gradient is less than 12 % (cropping land) or 30 % (grassland) and distinct soil erosion is evident. For example soils in “Thalways” are prone to erosion at very weak gradients.
Just water erosion risk assessments are scale-dependent and may extremely differ between nations and continents. For example, the classification of prime farmland (Soil Survey Staff, 1993, 2006) permits a criterion of erodibility K*S= <2 (K=soil factor, S=slope factor). In Germany, the potential risk of water erosion is classified as very high if K*S > 0.3 (Deumlich et al, 2007). At a given Loess soil prone to erosion of K= 0.5 the acceptable slope gradient would be 22 % (prime farmland criterion) or 12 % (criterion in Germany, matching to Table 3.3.9.-1).
The list of hazard factors is extendable as from the conception the lowest multiplier will be valid.

**Fig. 3.3.13.-1: Streambank erosion at 1999 flood. Location in Canterbury, New Zealand**

**Table 3.3.13.-1: Scoring of Miscellaneous hazards**

| Score | Characteristic | Multiplier arable land | Multiplier grassland |
|---|---|---|---|
| **2** | No | 3 | 3 |
| **1.5** | Low | 2 - 3 | 2.5 - 3 |
| **1** | Medium | 1 - 2 | 2 - 2.5 |
| **0.5** | High | 0.5 - 1 | 1 - 2 |
| **0** | Very high | < 0.5 | < 1 |

### 3.4. Rules of final rating

In general, the lowest hazard multiplier will be multiplied with the basic score. If two ore more hazard indicators are sub- optimum, final ratings should follow Table 3.4.1.

**Table 3.4.-1: Rules of final rating**

| Number of sub-optimum Hazard Indicators (rating < 2) | Remarks | Rule |
|---|---|---|
| 1 | | Basic score * hazard multiplier |
| 2 | Both have same rating | Basic score * multiplier of the most serious indicator,<br>Multiplier less than average within the range |

| | | |
|---|---|---|
| 2 | Both different | Basic score * lowest hazard multiplier |
| 3 | No steep slope | Basic score * multiplier of the most serious indicator,<br>Multiplier at minimum of the range |
| 3 | Steep slope | Basic score * multiplier of the most serious indicator,<br>Multiplier in the range of 1 rating class deeper |
| 4 or more | No steep slope | Basic score * multiplier of the most serious indicator,<br>Multiplier in the range of 1 rating class deeper |
| 4 or more | Steep slope | Basic score * multiplier of the most serious indicator,<br>Multiplier in the range of 2 rating classes deeper |

## 3.5. Diagnostic check of the results

In a final stage of rating the results in terms of SQR score and classes of soil quality should experience a diagnostic check to avoid misclassifications (Table 3.5.1.).

**Table 3.5.1: Diagnostic check of the final rating score (SQR score) of cropping land**

| **SQR score** | **Soil quality assessment** | **Criteria to meet** |
|---|---|---|
| < 20 | Very poor | |
| 20-40 | Poor | - Save cropping of a main basic crop [4] |
| 40-60 | Moderate | - Criteria of unique farmland [1]<br>- Save cropping of corn [3] |
| 60-80 | Good | - Criteria of farmland of statewide importance [1]<br>- Save cropping of winter wheat in Eurasia and Northern America |
| > 80 | Very good | - Criteria of prime farmland [1]<br>- Acceptable risk of water and wind erosion [2]<br>- Save cropping of maize for corn |

[1] http://en.wikipedia.org/wiki/Prime_farmland, Soil Survey Staff (1993). Soil Survey Manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. Retrieved on 2006-08-30.
[2] Soil loss less than tolerable limit, for example methodics of water erosion risk assessment acc. to Deutsche Norm, DIN 19708 (2005) and Bavarian LfL (2004), wind erosion acc. to Deutsche Norm, DIN 19706 (2004)
[3] Cereal of highest local importance (maize, wheat, barley, rye, millet and others)
[4] Crop adapted to local conditions that provides subsistence farming (basic food of humans, for animal husbandry or a cash crop like potato, buckwheat or others)

# 4. Outlook

The Muencheberg SQR is an empirical rating system. The approach presented here has been developed and tested in the temperate climatic zone.
As the method includes the majority of soil hazard properties occurring worldwide, their validity should cover a larger range of soils suitable for cropping or grazing in different climatic zones and can thus provide a comparison of soil quality over large areas.

Sufficient correlations of the rating score with the crop yield potential are to be expected within climatic subzones and at a defined level of farming.

**Fig. 4.-1: Extremely acid and sulphur-contaminated soil, not suitable for farmland. Only extremely adapted native brushes (*Leptospermum scoparium*, Manuka) can grow.**
**Basis score = 14, Hazard score = 0, Multiplier < 0.05 (0.01), Total SQR score = 1. Thionic Leptosol.**
**Location: Rotorua, New Zealand**

**Fig. 4.-2: Prime farmland soil for cropping. Haplic Chernozem (Siltic) from loess. Basic score 32, No hazard limitations, Multiplier= 2.94, Total SQR score 94. Location Rossdorf near Marburg, Germany**

The approach has potential for modifications at different levels of evaluating soil properties.

Authors appreciate field tests on feasibility of this system worldwide. They are hopeful on applicability at different regions and spatial scales because of its simplicity, robustness and relatively fast handling.

**A note on further orientation guides:**
The World Resources Map index (USDA/NRCS, 2005, **(http://soils.usda.gov/use/worldsoils/mapindex/)** gives a rough orientation on Global Soil Temperature Moisture Regimes, Soil Regions, Biomes and Risks of land use. The FAO has similar data available (FAO, 2000: Global Agro-Ecological Zones).
If sites have been classified by WRB, 2006, Appendix 2 of this manual will provide a list of orientation scores according to soil reference groups and their qualifiers.

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Appendix 1: Examples of soil scoring

## *Examples of Muencheberg SQR:* Seelow Silty Clay, Germany

### Muencheberg Soil Quality Rating (SQR)

*Cropping land*

**Score card, Page 1: Basic soil data**

| | |
|---|---|
| **Location name:** | Seelow, Oderbruch region, Germany |
| **Coordinates:** | 52°32`28.97``N, 14°26`35.99``E, elevation 7.4 m |
| **Soil name:** | Seelow Silty Clay, Profile G1/2 |
| **Land use:** | Annual cropping (winter wheat, maize, sunflower) |
| **Landform and topography:** | River basin (former floodplain), flat |
| **Date and Name of rating person:** | 22.11.04, L. Mueller |

## *Soil profile data:* Seelow Silty Clay

| m | Pedon field description | | | | | |
|---|---|---|---|---|---|---|
| | Texture class | | Horizon | Humus % | Water table | Gravel, Stones |
| | USDA/FAO | National | | | | |
| 0.1 | | | | | | |
| 0.2 | SiC ↓ | Tu2 ↓ | Sw-rAp | 4.2 | | None↓ |
| 0.3 | | | | | | |
| 0.4 | | | | | | |
| 0.5 | | | Sd-rGo-M | 3.1 | | |
| 0.6 | | | | | High | |
| 0.7 | | | Sd-M-Go | | | |
| 0.8 | | | | 2 | | |
| 0.9 | | | | | | |
| 1.0 | | | | | Mean∇ | |
| 1.1 | | | | | | |
| 1.2 | | | | | | |
| 1.3 | | | | | | |
| 1.4 | | | | | Low | |
| 1.5 | | | | | | |

**Soil classification**

| | |
|---|---|
| **Local** | Pseudovergleyter Vega-Gley-Reliktgley aus Auenton |
| **WRB** | Gleyic Fluvisol |
| **WRB 2006** | Gleyic Fluvisol (Humic, Eutric, Clayic, Drainic) |
| **US Taxonomy** | |
| **Remarks:** | Former backwater area of the Oder river, drained polder, water table 0.7 to 1.4 m below surface, fluctuating, drainage class: Imperfect<br>German soil assessment: LT 5 Al, 54/54 |

References to further date on soil profile and landscape: Excursion guide Oderbruch: http://www.zalf.de/home_zalf/institute/blf/blf_e/mitarbeiter/mueller/pdf/exkurs.pdf

## *Examples of Muencheberg SQR:* Seelow Silty Clay, Germany

# Muencheberg Soil Quality Rating (SQR)

*Cropping land*

### Score card, Page 2: Relevant criteria of Basic Rating

| Indicator | Relevant criteria of Basic Rating | Pedon data |
|---|---|---|
| **Soil substrate** | Soil texture class over the upper 80 cm 50 cm | SiC |
| | Parent material of soil | Alluvium |
| | Strong gradients of texture within 80 cm (layering)? | None |
| | Content of coarse material > 2 mm over 80 cm (cropping) or 50 cm (grassland) | < 1 % |
| | SOM of topsoil (upper 20 cm) | 4.2 % |
| | Proportion of concretions or artefacts | None |
| **A horizon depth and depth of humic soil** | A-horizon depth (cm) | 20 |
| | Depth of OM content > 4% | 30 |
| | Abrupt change from topsoil to subsoil ? | No |
| **Topsoil structure** | Type of topsoil aggregates | Angular to subangular blocky |
| | Size of topsoil aggregates | Medium |
| | Ratings of Peerlkamp, Diez, or Shepherd- VSA or other soil structure ratings | VSA structure and porosity ratings < 1 (medium to low) |
| **Subsoil compaction** | Increased soil strength or density at 30-50 cm depth? | Slight |
| | Redoximorphic feature in the topsoil and upper subsoil? | Slight |
| | Tillage pan score VSA | 1.5 (slight) |
| | Other subsoil compaction features | Blocky structure |
| **Rooting depth and biological activity** | Abundance of roots | Few |
| | Barriers to rooting | Springtime watertable at 0.8 m |
| | Effective rooting depth **AG Boden, 2005, p. 356** | < 0.8 m |
| | Zustandsstufe Bodenschaetzung **AG Boden, 2005, p. 318** | V |
| | Abundance of deep burying earthworms (Grassland) | Few |
| | Abundance of moles (Grassland) | |
| **Profile available water** | Depth of watertable | 0.8-1.5 m |
| | Water storage capacity of soil | Very high |
| | Grassland Wasserstufe | 2-/2+ |
| **Wetness and ponding** | Depth of ground or perched water table | 0.8 (slight wetness) |
| | Soil drainage class | Imperfect |
| | Degree of redoximorhphic features in the subsoil | Slight |
| | Indicator values of vegetation | |
| | Soil position in a depression ? | No, land is level |
| | Wetness by suspended water (soils rich in silt and clay or muck) ? | Yes |
| | Ponding during soil assessment | No |
| | Delay of begin of farming on cropping land (days) | < 7 days as compared with soils in the vicinity |
| **Slope and relief** | Slope at the pedon position | level |
| | Microrelief and slope aspect at the pedon position | |

## *Examples of Muencheberg SQR:* Seelow Silty Clay, Germany

### Muencheberg Soil Quality Rating (SQR)

*Cropping land*

**Score card, Page 3: Basic Rating**

| Basic indicators | | Score | Weighting factor | Total | Remarks |
|---|---|---|---|---|---|
| 1 | Soil substrate | **1.5** | 3 | **4.5** | Clay soil, Table 3.2.1.-1 |
| 2 | A horizon depth | **1.5** | 1 | **1.5** | 20 cm, Table 3.2.2.-1 |
| 3 | Topsoil structure | **1** | 1 | **1** | Unfavourable aggregate features, Table 3.2.3.-1 |
| 4 | Subsoil compaction | **1.5** | 1 | **1.5** | Few signs of compaction, Table 3.2.4.-1 |
| 5 | Rooting depth (RD) | **1** | 3 | **3** | RD 0.8-1.1 m, limited by water table, Table 3.2.5.-1 |
| 6 | Profile available water (PAW) | **2** | 3 | **6** | > 220 mm due to capillary supply, Table 3.2.6.-1 |
| 7 | Wetness and ponding | **0.5** | 3 | **1.5** | Moderate ponding and additional perched water, Table 3.2.7.-1 |
| 8 | Slope and relief | **2** | 2 | **4** | Flat, no limitations, Table 3.2.8.-1 |
| Total basic score | | | | **23** | Medium score, maximum would be 34 |

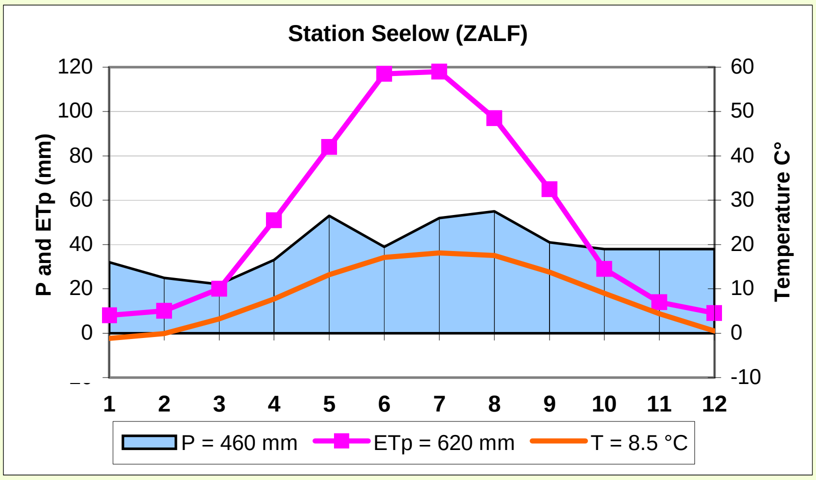
**Winter wheat on Seelow Silty Clay, *Phragmites australis* indicates wetness problems**

## Muencheberg Soil Quality Rating (SQR)

*Cropping land*

### Score card, Page 4: Vegetation and climate data

| | |
|---|---|
| Landuse | *Cropping land, ploughless* |
| Main species of vegetation | Cropping plants: winter wheat, maize, sunflower<br>Weeds: *Agropyron repens, Phragmites australis* |
| **Vegetation indicators** | Ellenberg : F= 6-7 , Wasserstufe 2-/3+ |
| Above ground biomass | 8-12 t/ha*yr, 4-6.5 t/ha*yr grain of wheat |
| Main biome (potential natural vegetation) | Temperate forest |




**Climate**:

Precipitation: 460 mm/a,
Temperature: 8-9° C,
Koeppen climatic zone: Cfb

**Monthly temperature, °C**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1,2 | -0,1 | 3,2 | 7,7 | 13,2 | 17,1 | 18,1 | 17,5 | 13,8 | 9 | 4,4 | 0,5 | 8,5 |

**Agroecological data:**

| | |
|---|---|
| Latest/ first frost (p> 10 %) | May, 13 / Oct, 10 |
| Begin of vegetation period (t> 5°C) | March, 25 |
| Length of growing period (t>5°/ t> 10°) | 250 / 190 days |
| Temperature sum (t>5°/ t> 10°) | 3500 / 3000 |
| Depth of soil freezing | 40 cm |
| Snow days during winter | 10-20 % |

## Muencheberg Soil Quality Rating (SQR)

*Cropping land*

### Score card, Page 5: Criteria of Hazard rating

| **Indicator** | **Relevant criteria of Hazard Rating** | **Pedon data** |
|---|---|---|
| Contamination | Position in a risk area? | None |
| Salinization | Electric conductivity | |
| | Salt crusts or coatings | None |
| | Salt indicator vegetation | None |
| Sodification Acidification | pH | 6.5 |
| | SAR | |
| | ESP | |
| Low total nutrient status | Malnutrition features of crops ? | None |
| Soil depth above hard rock | | > 50 m |
| Drought | Water budget mm/yr | > 500 |
| | Climatic water balance in the main vegetation period of 4 months | |
| | Benefit of irrigation | |
| | Probability of the occurrence of a dry month | |
| | Aridity index acc. to De Martonne | |
| | Bailey moisture index | |
| | Ombrothermic index Io) of Rivas-Martínez (1997) | |
| Flooding and extreme waterlogging | Inundation frequency and duration | None |
| | Water regime class of Soil Survey Manual | Imperfect |
| | Benefit of land drainage | Moderate to low |
| Steep Slope | Slope % | 0 |
| Rock at the surface | | None |
| Coarse soil texture fragments | | None |
| Unsuitable soil thermal regime | Soil thermal regime | None |
| Miscellaneous hazards | | None |
| Remarks | | |

## *Examples of Muencheberg SQR:* Seelow Silty Clay, Germany

# Muencheberg Soil Quality Rating (SQR)

*Cropping land*

### Score card, Page 6: Final rating

| Hazard indicators | | Score | Range of multipliers | Multiplier | Remarks |
|---|---|---|---|---|---|
| 1 | Contamination | 2 | 3 | 3 | No limitations by hazard factors |
| 2 | Salinisation | 2 | 3 | 3 | |
| 3 | Sodification | 2 | 3 | 3 | |
| 4 | Acidification | 2 | 3 | 3 | |
| 5 | Low total nutrient status | 2 | 3 | 3 | |
| 6 | Soil depth above hard rock | 2 | 3 | 3 | |
| 7 | Drought | 2 | 3 | 3 | |
| 8 | Flooding and extreme waterlogging | 2 | 3 | 3 | |
| 9 | Steep Slope | 2 | 3 | 3 | |
| 10 | Rock at the surface | 2 | 3 | 3 | |
| 11 | Coarse soil texture fragments | 2 | 3 | 3 | |
| 12 | Unsuitable soil thermal regime | 2 | 3 | 3 | |
| 13 | Miscellaneous hazards | 2 | 3 | 3 | |
| **Lowest multiplier** | | | | **3 (2.94)** | |

**Final rating score (SQR score, rounded)** = Total basic score* lowest multiplier

**SQR score** = 23 * 2.94 = **68**

**Cropland Soil quality assessment**:
< 20= Very poor, 20 – 40 = Poor, 40 – 60= Moderate, 60 – 80 Good, > 80= Very good

**Comment on final rating:** Good cropping site, possible limitations due to temporary wetness and high clay content, associated with farm traffic induced sub-optimum soil structure, slight climatic drought risk can be compensated by capillary groundwater supply

# Muencheberg Soil Quality Rating (SQR)

***Grassland***

## Score card, Page 1: Basic soil data

| | |
|---|---|
| **Location name:** | Genschmar, Oderbruch, Germany |
| **Coordinates:** | 52°37`43.50``N, 14°32`24.21``E, elevation 10 m |
| **Soil name:** | Genschmar Sand, Profile G1/3 |
| **Land use:** | Grassland, Rangeland, nature conservation area, unfertilized pasture, grazing by cows and sheep |
| **Landform and topography:** | River floodplain, flat |
| **Date and Name of rating person:** | 22.11.04, L. Mueller |

## *Soil profile data:* Genschmar Sand

| m | Pedon field description | | | | | |
|---|---|---|---|---|---|---|
| | **Texture class** | | **Horizon** | **Humus %** | **Water table** | **Gravel, Stones** |
| | **USDA/FAO** | **National** | | | | |
| 0.1 | lS | St2 | Ah1 | 10 | | None↓ |
| 0.2 | | | Ah2 | 6 | | |
| 0.3 | | | ilCv | 3 | | |
| 0.4 | S (mS) ↓ | fSms | fAh | | | |
| 0.5 | | | | < 1↓ | | |
| 0.6 | | | | | | |
| 0.7 | | | | | | |
| 0.8 | | mS | ailCv | | | |
| 0.9 | | | | | | |
| 1.0 | | mSfs ↓ | aGo1 | | | |
| 1.1 | | | | | | |
| 1.2 | | | | | | |
| 1.3 | | | | | | |
| 1.4 | | | | | | |
| 1.5 | | | aGo2 | | 2.5 m | |

## Soil classification

| | |
|---|---|
| **Local** | Regosol über Paternia aus Kippsand über Fluvisand |
| **WRB**<br>**WRB 2006** | Dystric Fluvisol<br>Haplic Fluvisol (Dystric, Arenic) |
| **US Taxonomy** | |
| **Remarks:** | Pedon in the floodplain near the Oder river, fluvial sand covered by shallow eolic and anthropogenic sand deposit, water table 1.8 to 3.5 m below surface, fluctuating, flooding probability < 2 %, drainage class: E, German soil assessment: lS II a 4(-), 33/30 |

References to further date on soil profile and landscape: Excursion guide Oderbruch: http://www.zalf.de/home_zalf/institute/blf/blf_e/mitarbeiter/mueller/pdf/exkurs.pdf

## *Examples of Muencheberg SQR:* Genschmar Sand, Germany

# Muencheberg Soil Quality Rating (SQR)

*Grassland*

### Score card, Page 2: Relevant criteria of Basic Rating

| Indicator | Relevant criteria of Basic Rating | Pedon data |
|---|---|---|
| **Soil substrate** | Soil texture class over the upper 80 cm 50 cm | S |
| | Parent material of soil | Alluvium |
| | Strong gradients of texture within 80 cm (layering)? | None |
| | Content of coarse material > 2 mm over 80 cm (cropping) or 50 cm (grassland) | < 1 % |
| | SOM of topsoil (upper 20 cm) | 3 % |
| | Proportion of concretions or artefacts | None |
| **A horizon depth and depth of humic soil** | A-horizon depth (cm) | 25 |
| | Depth of OM content > 4% | 25 |
| | Abrupt change from topsoil to subsoil ? | No |
| **Topsoil structure** | Type of topsoil aggregates | Singular grain |
| | Size of topsoil aggregates | |
| | Ratings of Peerlkamp, Diez, or Shepherd- VSA or other soil structure ratings | VSA structure and porosity ratings < 1 (medium to low) |
| **Subsoil compaction** | Increased soil strength or density at 30-50 cm depth? | None |
| | Redoximorphic feature in the topsoil and upper subsoil? | None |
| | Tillage pan score VSA | 2 (No pan) |
| | Other subsoil compaction features | None |
| **Rooting depth and biological activity** | Abundance of roots | Few |
| | Barriers to rooting | Sandy soil substrate |
| | Effective rooting depth **AG Boden, 2005, p. 356** | 0.6 m |
| | Zustandsstufe Bodenschaetzung **AG Boden, 2005, p. 318/319** | II |
| | Abundance of deep burying earthworms (Grassland) | Few |
| | Abundance of moles (Grassland) | |
| **Profile available water** | Depth of watertable | 1.8-3.5 m |
| | Water storage capacity of soil | Very low |
| | Grassland Wasserstufe | 3- |
| **Wetness and ponding** | Depth of ground or perched water table | None |
| | Soil drainage class | Excessively drained |
| | Degree of redoximorhphic features in the subsoil | None |
| | Indicator values of vegetation | |
| | Soil position in a depression ? | No, land is level |
| | Wetness by suspended water (soils rich in silt and clay or muck) ? | No |
| | Ponding during soil assessment | No |
| | Delay of begin of farming on cropping land (days) | No |
| **Slope and relief** | Slope at the pedon position | level |
| | Microrelief and slope aspect at the pedon position | |

## Muencheberg Soil Quality Rating (SQR)

***Grassland***

### Score card, Page 3: Basic Rating

| Basic indicators | | Score | Weighting factor | Total | Remarks |
|---|---|---|---|---|---|
| 1 | Soil substrate | 0.5 | 3 | 1.5 | Sand, Table 3.2.1.-1 |
| 2 | Depth of humic soil | 1 | 2 | 2 | 0.15- 0.3 m, Table 3.2.2.-2 |
| 3 | Topsoil structure | 1 | 1 | 1 | Single grain, Diez score 3-4 Table 3.2.3.-1 |
| 4 | Subsoil compaction | 2 | 1 | 2 | None, Table 3.2.4.-2 |
| 5 | Biological activity | 1 | 2 | 2 | Less than 15 cm, Table 3.2.5.-3 |
| 6 | Profile available water (PAW) | 0.5 | 3 | 1.5 | Strong deficite, Wasserstufe 4-, Table 3.2.6.-1 |
| 7 | Wetness/ ponding | 2 | 3 | 6 | None, Table 3.2.7.-1 |
| 8 | Slope and relief | 2 | 2 | 4 | Flat, Table 3.2.8.-1 |
| Total basic score (TBS) | | | | **20** | Medium score, maximum would be 34 |

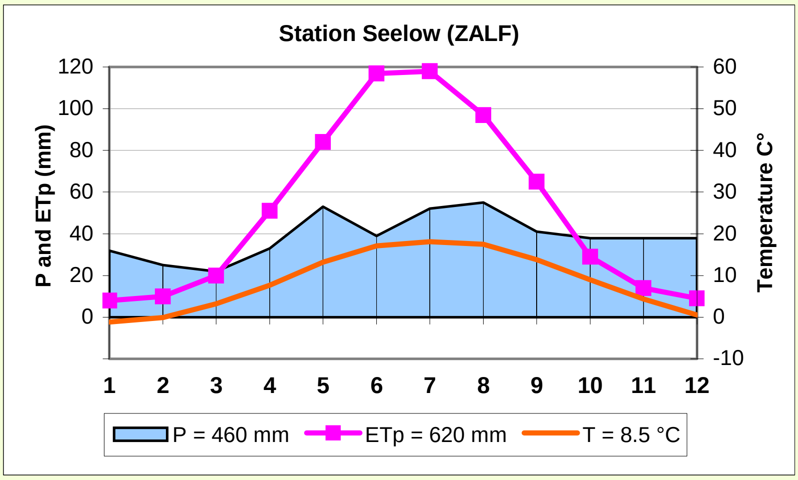
**Grazing cattle on Genschmar sand, elevated position in the floodplain of the Oder river**

## Muencheberg Soil Quality Rating (SQR)

***Grassland***

### Score card, Page 4: Vegetation and climate data

| | |
|---|---|
| Landuse | |
| Main species of vegetation | *Agropyron repens, Calamagrostis epigejos, Rumex acetosa, Carex praecox, Alopecurus pratensis* |
| **Vegetation indicators** | Ellenberg :F= 4.6, Wasserstufe 3- to 4- |
| Above ground biomass | 3-5 t/ha*yr |
| Main biome (potential natural vegetation) | |




**Climate**:
Precipitation: 460-500 mm/a Temperature: 8-9° C
Koeppen climatic zone: Cfb

**Monthly temperature, °C**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1,2 | -0,1 | 3,2 | 7,7 | 13,2 | 17,1 | 18,1 | 17,5 | 13,8 | 9 | 4,4 | 0,5 | 8,5 |

**Agroecological data:**

| | |
|---|---|
| Latest/ first frost (p> 10 %) | May, 13 / Oct, 10 |
| Begin of vegetation period (t> 5°C) | March, 25 |
| Length of growing period (t>5°/ t> 10°) | 250 / 190 days |
| Temperature sum (t>5°/ t> 10°) | 3500 / 3000 |
| Depth of soil freezing | 40 cm |
| Snow days during winter | 10-20 % |

## Muencheberg Soil Quality Rating (SQR)

*Grassland*

### Score card, Page 5: Criteria of Hazard rating

| Indicator | Relevant criteria of Hazard rating | Pedon data |
|---|---|---|
| Contamination | Position in a risk area? | Yes, located in a floodplain |
| Salinization | Electric conductivity | |
| | Salt crusts or coatings | None |
| | Salt indicator vegetation | None |
| Sodification Acidification | pH | 4.6-5.6 |
| | SAR | |
| | ESP | |
| Low total nutrient status | Malnutrition features of crops ? | None |
| Soil depth above hard rock | | No hard rock |
| Drought | Water budget mm/yr | 450 |
| | Climatic water balance in the main vegetation period of 4 months | 210 mm deficit |
| | Benefit of irrigation | |
| | Probability of the occurrence of a dry month | |
| | Aridity index acc. to De Martonne | |
| | Bailey moisture index | |
| | Ombrothermic index Io) of Rivas-Martínez (1997) | |
| Flooding and extreme waterlogging | Inundation frequency and duration | High position in the risk area, flooding probability < 2 times per 100 yrs |
| | Water regime class of Soil Survey Manual | Excessive |
| | Benefit of land drainage | None |
| Steep Slope | Slope % | 0 |
| Rock at the surface | | None |
| Coarse soil texture fragments | | None |
| Unsuitable soil thermal regime | Soil thermal regime | None |
| Miscellaneous hazards | | None |
| Remarks | | |

## *Examples of Muencheberg SQR:* Genschmar Sand, Germany

# Muencheberg Soil Quality Rating (SQR)

***Grassland***

### Score card, Page 6: Final rating

| Hazard indicators | | Score | Range of multipliers | Multiplier | Remarks |
|---|---|---|---|---|---|
| 1 | Contamination | 2 | 3 | 3 | Slight limitations by flooding, medium by drought, water budget about 450 mm, low risk of riverbank erosion |
| 2 | Salinisation | 2 | 3 | 3 | |
| 3 | Sodification | 2 | 3 | 3 | |
| 4 | Acidification | 2 | 3 | 3 | |
| 5 | Low total nutrient status | 2 | 3 | 3 | |
| 6 | Soil depth above hard rock | 2 | 3 | 3 | |
| 7 | Drought | 1.5 | 2-3 | 2.2 | |
| 8 | Flooding and extreme waterlogging | 1.5 | 2.5-3 | 2.7 | |
| 9 | Steep Slope | 2 | 3 | 3 | |
| 10 | Rock at the surface | 2 | 3 | 3 | |
| 11 | Coarse soil texture fragments | 2 | 3 | 3 | |
| 12 | Unsuitable soil thermal regime | 2 | 3 | 3 | |
| 13 | Miscellaneous hazards: Risk of riverbank erosion | 1.5 | 2.5-3 | 2.7 | |
| **Lowest multiplier** | | | | **2.2** | |
| ***Final Multiplier acc. to Table 3.4.-1*** | | | | **2.0** | |

**Final rating score (SQR score, rounded)** = Total basic score* Lowest multiplier

**SQR score** = 20 * 2.0 = **40**

**Grassland Soil quality assessment**:
< 20= Very poor, 20 – 40 = Poor, 40 – 60= Moderate, 60 – 80 Good, > 80= Very good

**Comment on final rating:** Poor to moderate grassland site, main limitations by drought

## Appendix 2: Orientation guides of indicator scoring based on properties of Soil Reference Groups (SRG) and qualifiers of WRB, 2006

Note : Following Tables indicate only those limitations that are very highly probable to exist because of conflicting definitions of SRG and qualifiers with definitions and thresholds of Basic and Hazard soil rating tables.

### Table A2-1: Limitations of Basic indicators based on SRG

| Reference Soil Groups | Soil substrate | A horizon depth | Topsoil structure | Subsoil compact-ion | Rooting depth | Profile available water | Wetness and ponding | Slope and relief |
|---|---|---|---|---|---|---|---|---|
| Acrisol AC | **≤1.5** (1) | (1) | (1) | (1) | **≤1.5** (1) | (1) | (1.5) | (1) |
| Albeluvisol AB | (1) | (1.5) | (1) | (1.5) | (1) | (1) | (1.5) | (1.5) |
| Alisol AL | **≤1.5** (1) | (1) | (1) | (1) | **≤1.5** (1) | (1) | (1) | **≤1.5** (1) |
| Andosol AN | (1.5) | (1.5) | (1.5) | (1.5) | (2) | (2) | (2) | **≤1.5** (1) |
| Anthrosol AT | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) |
| Arenosol AR | **≤1** (0.5) | (1) | (1) | (1) | **≤1** (0.5) | (0.5) | (2) | (1.5) |
| Calcisol CL | **≤1.5** (0.5) | (0.5) | (0.5) | (1) | **≤1.5** (0.5) | (0.5) | (1.5) | (1.5) |
| Cambisol CM | (1) | (1.5) | (1.5) | (1) | (1.5) | (1.5) | (1.5) | (1.5) |
| Chernozem CH | **≥0.5** (2) | (2) | (1.5) | (1.5) | (1.5) | (1.5) | (2) | (2) |
| Cryosol CR | (0.5) | (0.5) | (1) | (1) | **≤1.5** (0.5) | (1.5) | **≤1.5** (0.5) | (1.5) |
| Durisol DU | **≤1.5** (0.5) | (0.5) | (0.5) | (0.5) | **≤1.5** (0.5) | (1) | (2) | (1.5) |
| Ferralsol FR | **≤1** (1) | (1) | (1) | (1) | (1.5) | **≤1.5** (1) | (1.5) | (1) |
| Fluvisol FL | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) | (1.5) | **≥1** (2) |
| Gleysol GL | (1) | (1) | (1) | (1) | **≤1.5** (1) | (2) | **≤1.5** (0.5) | **≥1** (2) |
| Gypsisol GY | **≤1** (0.5) | (0.5) | (0.5) | (1) | **≤1.5** (0.5) | (0.5) | (1.5) | (1) |
| Histosol HS | **1-1.5** (1) | (1.5) | (1.5) | (1.5) | **≤1.5** (1) | **≥1** (2) | (0.5) | **≥1** (2) |
| Kastanozem KS | (2) | (1.5) | (1.5) | (1.5) | (1.5) | (1) | (2) | (2) |
| Leptosol LP | **≤1** (0.5) | **≤1.5** (0.5) | (1) | (0.5) | **≤1** (0.5) | (0.5) | (1.5) | (0.5) |
| Lixisol LX | **≤1.5** (1) | (1.5) | (1) | (1) | (1) | (1) | (1.5) | (1) |
| Luvisol LV | (1.5) | (2) | (1) | (1) | (1.5) | (1.5) | (1.5) | (1.5) |
| Nitisol NT | **≤1.5** (1) | (1.5) | (1.5) | (1.5) | (1.5) | (1) | (1.5) | (1) |
| Phaeozem PH | (2) | (1.5) | (1.5) | (1.5) | (2) | (1.5) | (2) | (2) |
| Planosol PL | **≤1** (1) | (0.5) | (0.5) | **≤1** (1) | **≤1** (1) | **≤1.5** (1) | **≤1.5** (1) | **≥1** (1.5) |
| Plinthosol PT | **≤1.5** (1) | (1) | (0.5) | **≤1.5** (0.5) | **≤1.5** (0.5) | (1) | (1) | (1.5) |
| Podzol PZ | **≤1.5** (1) | (1) | (0.5) | (1) | **≤1.5** (1) | **≤1.5** (1) | (1.5) | (1) |
| Regosol RG | (1) | (1) | (1) | (1) | (1) | (1) | (1.5) | (1) |
| Solonchak SC | **≤1.5** (0.5) | (0.5) | (1) | (1.5) | **≤1** (1) | (1) | **≤1.5** (1) | **≥1** (1.5) |
| Solonetz SN | **≤1.5** (1) | (1) | (1) | (1.5) | **≤1** (1) | (1) | **≤1.5** (1) | **≥1** (1.5) |
| Stagnosol ST | (1) | (1.5) | (1) | (1) | **≤1** (1) | **≤1.5** (1) | **≤1.5** (0.5) | (1.5) |
| Technosol TC | **≤0.5** (0.5) | (1) | (1) | (1) | (1) | (1) | (1) | (1.5) |
| Umbrisol UM | (1.5) | (1.5) | (1) | (1) | (1) | (2) | (1) | (0.5) |
| Vertisol VR | **1** | (1.5) | (1) | (1) | (1.5) | (1.5) | **≤1.5** (1) | **≥1** (1.5) |

### Table A2-2: Limitations of Basic indicators based on qualifiers

| Qualifiers | Soil substrate | A horizon depth | Topsoil structure | Subsoil compact-ion | Rooting depth | Profile available water | Wetness and ponding | Slope and relief |
|---|---|---|---|---|---|---|---|---|
| Abruptic ap | **≤1.5** (1) | | | | **≤1.5** (1) | | **≤1.5** | |
| Aceric ae | **≤1** (1) | | | | **≤1** (0.5) | | | |
| Acric ac | **≤1** (1) | | | | | | | |
| Acroxic ao | **≤1.5** (1) | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Albic ab | | | | | | | | |
| Alcalic ax | **≤1** (0.5) | | | | **≤1** (0.5) | | | |
| Alic al | **≤1** (1) | | | | | | | |
| Aluandic aa | | | | | | | | |
| Thaptaluandic | | | | | | | | |
| Alumic au | **≤1** (0.5) | | | | **≤1** (0.5) | | | |
| Andic an | | | | | | | | |
| Anthraquic aq | | | **≤1** (1) | **≤1** (0.5) | **≤1** (0.5) | | | (2) |
| Anthric am | **≥1** | **≥1** (2) | | | | | | |
| Arenic ar | **≤1.5** (1) | | | | **≤1.5** (1) | **≤1.5** (1) | | |
| Epiarenic arp | **≤1** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Endoarenic arn | **≤1.5** (1) | | | | **≤1.5** (1) | **≤1.5** (1) | | |
| Aric ai | | | | | | | | |
| Aridic ad | **≤1** (1) | **≤1.5** (1) | | | | | | |
| Arzic az | **≤1** (0.5) | | | | **≤0.5** (0.5) | | **≤1.5** (0.5) | |
| Brunic br | **≤1** (0.5) | | | | **≤1** (0.5) | **≤1.5** (1) | | |
| Calcaric ca | | | | | | | | |
| Calcic cc | | | | | | | | |
| Cambic cm | | | | | | | | |
| Carbic cb | **≤1.5** (1) | | | | | | | |
| Carbonatic cn | **≤1.5** (0.5) | | | | **≤1.5** (1) | | | |
| Chloridic cl | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Chromic cr | | | | | | | | |
| Clayic ce | **≤1.5** (1) | | | | **≤1.5** (1) | | (1) | |
| Epiclayic cep | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Endoclayic cen | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Colluvic co | | | | | | | | |
| Cryic cy | | | | | **≤1.5** (1) | | | |
| Cutanic ct | | | | | | | | |
| Densic dn | | | | **≤0.5** | **0** (0) | **≤1.5** (0.5) | | |
| Drainic dr | | | | | | | **≥0.5** (1) | |
| Duric du | | | | | **≤1.5** (1) | | | |
| Endoduric nd | **≤1.5** (1) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Hyperduric duh | **≤1.5** (1) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Dystric dy | **≤1.5** (1.5) | | | | | | | |
| Orthodystric dyo | **≤1.5** (0.5) | | | | **≤1.5** (1) | | | |
| Ekranic ek | **0** | **≤1.5** (0.5) | **0** | **≤0.5** (0.5) | **≤1** (1) | **≤0.5** (0.5) | | |
| Endodystric ny | **≤1.5** (1.5) | | | | | | | |
| Endoeutric ne | | | | | | | | |
| Endofluvic nf | | | | | | | | |
| Endogleyic ng | **≤1.5** (1) | | | | **≤1** (1) | | **≤1.5** (1.5) | |
| Endoleptic nl | **≤1** (1) | | | | **≤1** (1) | | | |
| Endosalic ns | | | | | **≤1** (1) | | | |
| Entic et | | | | | | | | |
| Epidystric ed | **≤1.5** (1) | | | | | | | |
| Epieutric ee | | | | | | | | |
| Epileptic el | **≤1** (0.5) | | | | **≤1** (0.5) | | | |
| Epigleyic eg | **≤1.5** (1) | | | | **≤0.5** (0.5) | | **≤1.5** (0.5) | |
| Episalic ea | **≤0.5** (0.5) | | | | **≤0.5** (0.5) | | | |
| Escalic ec | | | | | | | | **2** |
| Eutric eu | | | | | | | | |
| Orthoeutric euo | | | | | **≤1** (1.5) | | | |
| Eutrosilic es | | | | | | | | |
| Ferralic fl | **≤1.5** (1) | | | | | | | |
| Hyperferralic flh | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Hypoferralic flw | | | | | | | | |
| Ferric fr | **≤1** (1) | | | | **≤1.5** (1) | | | |
| Hyperferric frh | **≤1** (0.5) | | | | **≤1.5** (1) | **≤1.5** (1) | | |
| Fibric fi | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Floatic ft | **≤1.5** (0.5) | | | **2** | **≤0.5** | **2** | **0** | **2** |
| Fluvic fv | | | | | | | | |
| Folic fo | **≤1** (0.5) | | **≤1.5** (1) | | | | | |
| Thaptofolic | | | | | **≤1** (1) | | | |
| Fractipetric fp | **≤1** (1) | | | | **≤1.5** (1) | | | |
| Fractiplinthic fa | **≤1** (1) | | | | **≤1.5** (1) | | | |
| Fragic fg | **≤1** (1) | | | **≤1.5** (1) | **≤1.5** (1) | | | |
| Fulvic fu | | | | | | | | |
| Garbic ga | **≤1.5** (1) | | | | | | | |
| Gelic ge | | | | | **≤1.5** (1) | | | |
| Gelistagnic gt | | | | | **≤0.5** (0.5) | | **≤0.5** (0.5) | |
| Geric gr | **≤1.5** (1) | | **≤1.5** (1) | | **≤1.5** (1) | | | |
| Gibbsic gi | | | | | | | | |
| Glacic gc | **≤1** (0.5) | | | | **≤1** (0.5) | | **≤1.5** (0.5) | |
| Gleyic gl | | | | | **≤1.5** (1.5) | | | |
| Glossalbic gb | | | | | | | | |
| Glossic gs | | | | | | | | |
| Greyic gz | | | | | | | | |
| Grumic gm | | | | | | | | |
| Gypsic gy | **≤1.5** (1) | | | | **≤1** (0.5) | **≤1.5** (1) | | |
| Gypsiric gp | **≤1** (1) | | | | **≤1.5** (1) | | | |
| Haplic ha | | | | | | | | |
| Hemic hm | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Histic hi | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Thaptohistic hib | **≤1.5** (1.5) | | | | **≤1.5** (1.5) | | | |
| Hortic ht | **≥1** (1.5) | **≥1** (1.5) | | | | | | |
| Humic hu | | | | | | | | |
| Hyperhumic huh | **≥1.5** (2) | **2** | | | | | | |
| Hydragric hg | **≤1.5** (1) | | **≤1** (0.5) | **≤1** (0.5) | **≤0.5** (0.5) | | **≤1.5** (0.5) | |
| Hydric hy | | | | | | | | |
| Hydrophobic hf | **≤1.5** (0.5) | | **≤1** (0.5) | | **≤1.5** (1) | | | |
| Hyperalbic ha | **≤1.5** (1) | | | | | | | |
| Hyperalic hl | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Hypercalcic hc | **≤1** (0.5) | | | | **≤1** (0.5) | | | |
| Hyperdystric hd | **≤1.5** (0.5) | | | | **≤1** (0.5) | | | |
| Hypereutric he | | | | | **≥1** (1.5) | | | |
| Hypergypsic hp | **≤1** (0.5) | | | | **≤1.5** (0.5) | | | |
| Hyperochric ho | **≤1.5** (0.5) | | **≤1** (0.5) | | **≤1.5** (0.5) | | | |
| Hypersalic hs | **≤1** (0.5) | | | | **≤1** (0.5) | **≤1** (0.5) | | |
| Hyperskeletic hk | **≤0.5** (0.5) | **≤1** (0.5) | **≤1.5** (1) | | **≤0.5** (0.5) | **≤1.5** (0.5) | | |
| Hypocalcic wc | | | | | | | | |
| Hypogypsic wg | | | | | **≤1.5** (1) | | | |
| Hypoluvic wl | | | | | | | | |
| Hyposalic ws | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Hyposodic wn | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Irragric ir | | | | | | | | |
| Lamellic ll | | | | | | | | |
| Laxic la | | | | | | | | |
| Leptic le | **≤1.5** (1) | | | | **≤1** (0.5) | | | |
| Lignic lg | **≤1** (1) | | | | **≤1.5** (0.5) | | | |
| Limnic lm | | | | | | | | |
| Linic lc | | | | | **≤1.5** (0.5) | | | |
| Lithic li | **0** | **≤0.5** (0) | | **0** | **0** | **0** | | |
| Lixic lx | | | | | | | | |
| Luvic lv | | | | | | | | |
| Magnesic mg | **≤1.5** (1) | | | | | | | |
| Manganiferric mf | **≤1** (1) | | | | **≤1.5** (1) | | | |
| Mazic mz | **≤1.5** (0.5) | | **≤0.5** (0.5) | | **≤1.5** (0.5) | | | |
| Melanic ml | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mesotrophic ms | | | | | | | | |
| Mollic mo | **≥1** (1.5) | **≥1** (1.5) | **≥1.5** (2) | | **≥1** (1.5) | **≥1** (1.5) | **≥1** (1.5) | |
| Molliglossic mi | **≥1** (1.5) | **≥1** (1.5) | **≥1.5** (2) | | **≥1** (1.5) | **≥1** (1.5) | **≥1** (1.5) | |
| Natric na | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Nitic ni | **≤1** (1) | | | | **≤1.5** (1.5) | | | |
| Novic nv | | | | | | | | |
| Areninovic anv | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Nudilithic nt | **0** | **0** | **0** | **0** | **0** | **0** | **0** | |
| Ombric om | **≤1** (1) | | | | **≤1.5** (0.5) | **≥1** (2) | **≤1** (0.5) | **≥1** (2) |
| Ornithic oc | | | | | | | | |
| Ortsteinic os | **≤1** (0.5) | | | **≤1.5** (0.5) | **≤1** (0.5) | | | |
| Oxyaquic oa | | | | | **≤1.5** (0.5) | | **≤1.5** (1) | |
| Pachic ph | **≥1** (2) | **≥1.5** (2) | **≥1.5** (2) | **≥1.5** (1.5) | **≥1.5** (1.5) | **≥1** (1.5) | **≥1** (1.5) | |
| Pellic pe | **≤1** (1) | **≤1** (1) | **≤1.5** (1) | | | | | |
| Petric pt | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Endopetric ptn | **≤1** (1) | | | | **≤1** (1) | **≤1.5** (1) | | |
| Epipetric ptp | **≤0.5** (0) | | | | **≤0.5** (0) | **≤1** (0.5) | | |
| Petrocalcic pc | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Petroduric pd | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Petrogleyic py | **≤1.5** (0.5) | | | | **≤1.5** (1) | | **≤1.5** (0.5) | |
| Petrogypsic pg | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Petroplinthic pp | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Petrosalic ps | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Pisoplinthic px | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Placic pi | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Plaggic pa | **≤1.5** (1) | **≥1** (2) | | | | | | |
| Plinthic pl | **≤1.5** (0.5) | | | | **≤1.5** (1) | **≤1.5** (0.5) | | |
| Posic po | | | | | | | | |
| Profondic pf | **≤1.5** (1) | | | | | | | |
| Protic pr | **≤1.5** (0) | **≤1** (0) | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Puffic pu | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Reductaquic ra | **≤1** (0.5) | | | | **≤1.5** (0.5) | | **≤1.5** (0.5) | |
| Reductic rd | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Regic rg | | | | | | | | |
| Rendzic rz | **≤1** (1) | | **≥1** (1.5) | | **≤1.5** (1) | | | |
| Rheic rh | **≤1.5** (1.5) | | | | **≤1.5** (1) | **≥1.5** (2) | **≤1.5** (1) | **≥1** (2) |
| Rhodic ro | | | | | | | | |
| Rubic ru | | | | | | | | |
| Ruptic rp | **≤1** (0.5) | | | | **≤1.5** (0.5) | | | |
| Rustic rs | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Salic sz | **≤1.5** (1) | | | | **≤1.5** (1.5) | **≤1.5** (1) | | |
| Sapric sa | **≤1.5** (1.5) | | | | **≤1.5** (1) | | | |
| Silandic sn | | | | | | | | |
| Thaptosilandic | **≤1.5** (1) | | | | | | | |
| Siltic sl | **≥1** (1.5) | | | | **≥1** (1.5) | | | |
| Endosiltic sln | **≥1** (1) | | | | **≥1** (1) | | | |
| Episiltic slp | **≥1** (2) | | | | **≥1** (1.5) | | | |
| Skeletic sk | **0** | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Endoskeletic | **≤1** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (1) | | |
| Episkeletic | **0** | | | **≤1** (0.5) | **≤1** (0.5) | **≤1.5** (0.5) | | |
| Sodic so | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Endosodic | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Solodic sc | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Sombric sm | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Spodic sd | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Spolic sp | **≤1** (0.5) | | | | **≤1** (0.5) | **≤1.5** (1) | | |
| Stagnic st | **≤1.5** (1) | | | | **≤1.5** (1) | **≤1.5** (1) | **≤1.5** (1) | |
| Endostagnic stn | **≤1.5** (1) | | | | **≤1** (1) | **≤1.5** (1) | **≤1.5** (1) | |
| Epistagnic stc | **≤1.5** (0.5) | | | | **≤0.5 (0)** | **≤1.5** (1) | **≤0.5** (0.5) | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subaquatic sq | **0** | **0** | **≤0.5 (0)** | **0** | **0** | **2** | **0** | **2** |
| Sulphatic su | **≤1.5** (0.5) | | | | **≤1.5** (0.5) | | | |
| Takyric ty | **0** | | **0** | | **≤1** (0.5) | **≤1** (1) | **≤1.5** (0.5) | **≥1.5** (2) |
| Technic te | **≤0.5** (0.5) | | **≤1.5** (1) | | **≤1.5** (1) | **≤1.5** (1) | | |
| Tephric tf | **≤1.5** (1.5) | | | | | | | |
| Terric tr | **≤0.5** (1) | **≥1** | | | | | | |
| Thaptandic ba | | | | | | | | |
| Thaptovitric bv | **≤1.5** (1) | | | | | | | |
| Thionic ti | **≤1.5** (0.5) | | | | **≤1.5** (1) | | | |
| Hyperthionic tih | **≤1** (0) | | | | **≤1** (0) | | | |
| Orthothionic tio | **≤1.5** (0) | | | | **≤1.5** (0.5) | | | |
| Protothionic tip | **≤1.5** (1) | | | | **≤1.5** (1) | | | |
| Thixotropic tp | **≤1** (0.5) | | **≤1** | | | | **≤1.5** (0.5) | |
| Tidalic td | **≤1.5** (0.5) | **≤1** (1) | **≤1.5** (1.5) | | **≥1.5** (0) | **≥1.5** (1.5) | **0** | **2** |
| Toxic tx | **0** | | | | **≤1** (0) | **≤1** (0) | | |
| Anthrotoxic atx | **0** | | | | **≤1** (0) | | | |
| Ecotoxic etx | **0** | | | | **≤1** (0) | | | |
| Phytotoxic ptx | **0** | | | | **≤1** (0) | | | |
| Zootoxic ztx | **0** | | | | **≤1** (0) | | | |
| Transportic tn | | | | | | | | |
| Turbic tu | **≤1.5** (1) | | | | | | | |
| Umbric um | **≤1.5** (1) | | **≤1.5** (1) | | | | | |
| Umbriglossic ug | **≤1.5** (1) | | **≤1.5** (1) | | | | | |
| Urbic ub | **0** | | **≤1** (1) | | **≤1** (1) | **≤1.5** (1) | | |
| Vermic vm | **≥1.5** (1.5) | **≥1.5** (1.5) | **≥1.5** (1.5) | **≥1** (1.5) | **≥1.5** (1.5) | **≥1.5** (1.5) | **≥1.5** (1.5) | |
| Vertic vr | **≤1** (1) | | **≤1** (1) | | **≤1.5** (1) | **≤1.5** (1) | **≤1.5** (1) | |
| Vetic vt | **≤1** (0.5) | | | | **≤1.5** (0.5) | **≤1.5** (0.5) | | |
| Vitric vi | **≤1.5** (1) | | | | | | | |
| Voronic vo | **≥1** (2) | **2** | **2** | | **≥1** (2) | **≥1** (2) | **≥1** (2) | **≥1** (2) |
| Xanthic xa | **≤1.5** (1) | | | | | | | |
| Yermic ye | **0** | **0** | **0** | | **≤1** (0.5) | **≤1** (0.5) | | |

**Table A2-3: Limitations of Hazard indicators based on SRG**

1. **Contamination**
2. **Salinisation**
3. **Sodification**
4. **Acidification**
5. **Low total nutrient status**
6. **Soil depth above hard rock**
7. **Drought**
8. **Flooding and extreme waterlogging**
9. **Steep slope**
10. **Rock at the surface**
11. **High percentage of coarse soil texture fragments**
12. **Unsuitable soil thermal regime**
13. **Miscellaneous hazards**

| **Reference Soil Groups** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acrisol AC | | | | **≤1.5** | **≤1.5** | | **≤1.5** | | | | | | |
| Albeluvisol AB | | | | | | | | | | | | | |
| Alisol AL | | | | | | | **≤1.5** | | | | | | |
| Andosol AN | | | | | | | | | | | | | |
| Anthrosol AT | | | | | | | | | | | | | |
| Arenosol AR | | | | | | | | | | | | | |
| Calcisol CL | | | | | | | **≤1.5** | | | | | | |
| Cambisol CM | | | | | | | | | | | | | |
| Chernozem CH | | | | | | | **≤1.5** | | | | | | |
| Cryosol CR | | | | | | | | | | | | **≤1.5** | |
| Durisol DU | | | | | | | **≤1** | | | | | | |
| Ferralsol FR | | | | | | | | | | | | | |
| Fluvisol FL | | | | | | | | | **2** | | | | |
| Gleysol GL | | | | | | | | | **2** | | | | |
| Gypsisol GY | | | | | **≤1.5** | | **≤1** | | | | | | |
| Histosol HS | | | | | | | | | **≥1** | | | | |
| Kastanozem KS | | | | | | | **≤1.5** | | | | | | |
| Leptosol LP | | | | | | **≤1** | | | | **≤1** | **≤1** | | |
| Lixisol LX | | | | | | | **≤1.5** | | | | | | |
| Luvisol LV | | | | | | | | | | | | | |
| Nitisol NT | | | | | | | | | | | | | |
| Phaeozem PH | | | | | | | | | | | | | |
| Planosol PL | | | | | | | | | **≥1.5** | | | | |
| Plinthosol PT | | | | | | | | | | | | | |
| Podzol PZ | | | | | | | | | | | | | |
| Regosol RG | | | | | | | | | | | | | |
| Solonchak SC | | **≤1.5** | | | | | **≤1.5** | | **≥1.5** | | | | |
| Solonetz SN | | | **≤1.5** | | | | **≤1.5** | | **≥1.5** | | | | |
| Stagnosol ST | | | | | | | | | | | | | |
| Technosol TC | | | | | | | | | | | **≤1.5** | | |
| Umbrisol UM | | | | | | | | | | | | | |
| Vertisol VR | | | | | | | | | **≥1.5** | | | | |

**Table A2-4: Limitations of Hazard indicators based on qualifiers**

| | |
|---|---|
| **1** | **Contamination** |
| **2** | **Salinisation** |
| **3** | **Sodification** |
| **4** | **Acidification** |
| **5** | **Low total nutrient status** |
| **6** | **Soil depth above hard rock** |
| **7** | **Drought** |
| **8** | **Flooding and extreme waterlogging** |
| **9** | **Steep slope** |
| **10** | **Rock at the surface** |
| **11** | **High percentage of coarse soil texture fragments** |
| **12** | **Unsuitable soil thermal regime** |
| **13** | **Miscellaneous hazards** |

| **Qualifiers** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abruptic ap | | | | | | | | | | | | | |
| Aceric ae | | | | | | | | | | | | | |
| Acric ac | | | | | | | | | | | | | |
| Acroxic ao | | | | | | | | | | | | | |
| Albic ab | | | | | | | | | | | | | |
| Alcalic ax | | | **≤1.5** | | | | | | | | | | |
| Alic al | | | | | | | | | | | | | |
| Aluandic aa | | | | | | | | | | | | | |
| Thaptaluandic | | | | | | | | | | | | | |
| Alumic au | | | | | | | | | | | | | |
| Andic an | | | | | | | | | | | | | |
| Anthraquic aq | | | | | | | | | | | | | |
| Anthric am | | | | | | | | | | | | | |
| Arenic ar | | | | | | | | | | | | | |
| Epiarenic arp | | | | | | | | | | | | | |
| Endoarenic arn | | | | | | | | | | | | | |
| Aric ai | | | | | | | | | | | | | |
| Aridic ad | | | | | | | | | | | | | |
| Arzic az | | | | | | | | | | | | | |
| Brunic br | | | | | | | | | | | | | |
| Calcaric ca | | | | | | | | | | | | | |
| Calcic cc | | | | | | | | | | | | | |
| Cambic cm | | | | | | | | | | | | | |
| Carbic cb | | | | | | | | | | | | | |
| Carbonatic cn | | | | | | | | | | | | | |
| Chloridic cl | | **≤1.5** | | | | | | | | | | | |
| Chromic cr | | | | | | | | | | | | | |
| Clayic ce | | | | | | | | | | | | | |
| Colluvic co | | | | | | | | | | | | | |
| Cryic cy | | | | | | | | | | | | | |
| Cutanic ct | | | | | | | | | | | | | |
| Densic dn | | | | | | | | | | | | | |
| Drainic dr | | | | | | | | | | | | | |
| Duric du | | | | | | | | | | | | | |
| Endoduric nd | | | | | | | | | | | | | |
| Hyperduric duh | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dystric dy | | | | | | | | | | | | | |
| Orthodystric dyo | | | | | | | | | | | | | |
| Ekranic ek | | | | | | | | | | | | **0** | |
| Endoduric nd | | | | | | | | | | | | | |
| Endodystric ny | | | | | | | | | | | | | |
| Endoeutric ne | | | | | | | | | | | | | |
| Endofluvic nf | | | | | | | | | | | | | |
| Endogleyic ng | | | | | | | | | | | | | |
| Endoleptic nl | | | | | | | **≤1.5** | | | | | | |
| Endosalic ns | | | | | | | | | | | | | |
| Entic et | | | | | | | | | | | | | |
| Epidystric ed | | | | | **≤1.5** | | | | | | | | |
| Epieutric ee | | | | | | | | | | | | | |
| Epileptic el | | | | | | | | | | | **≤1** | | |
| Epigleyic eg | | | | | | | | | | | | | |
| Episalic ea | | **≤1.5** | | | | | | | | | | | |
| Escalic ec | | | | | | | | | | | | | |
| Eutric eu | | | | | | | | | | | | | |
| Orthoeutric euo | | | | | | | | | | | | | |
| Eutrosilic es | | | | | | | | | | | | | |
| Ferralic fl | | | | | | | | | | | | | |
| Hyperferralic flh | | | | | | | | | | | | | |
| Hypoferralic flw | | | | | | | | | | | | | |
| Ferric fr | | | | | | | | | | | | | |
| Hyperferric frh | | | | | | | | | | | | | |
| Fibric fi | | | | | | | | | | | | | |
| Floatic ft | | | | | | | | **0** | | | | | |
| Fluvic fv | | | | | | | | | | | | | |
| Folic fo | | | | | | | | | | | | | |
| Thaptofolic | | | | | | | | | | | | | |
| Fractipetric fp | | | | | | | | | | | | | |
| Fractiplinthic fa | | | | | | | | | | | | | |
| Fragic fg | | | | | | | | | | | | | |
| Fulvic fu | | | | | | | | | | | | | |
| Garbic ga | | | | | | | | | | | | | |
| Gelic ge | | | | | | | | | | | | | |
| Gelistagnic gt | | | | | | | | **≤1.5** | | | | **≤1.5** | |
| Geric gr | | | | | | | | | | | | | |
| Gibbsic gi | | | | | | | | | | | | | |
| Glacic gc | | | | | | | | | | | | **≤1.5** | |
| Gleyic gl | | | | | | | | | | | | | |
| Glossalbic gb | | | | | | | | | | | | | |
| Glossic gs | | | | | | | | | | | | | |
| Greyic gz | | | | | | | | | | | | | |
| Grumic gm | | | | | | | | | | | | | |
| Gypsic gy | | | | | | | | | | | | | |
| Gypsiric gp | | | | | | | | | | | | | |
| Haplic ha | | | | | | | | | | | | | |
| Hemic hm | | | | | | | | | | | | | |
| Histic hi | | | | | | | | | | | | | |
| Thaptohistic hib | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hortic ht | | | | | | | | | | | | | |
| Humic hu | | | | | | | | | | | | | |
| Hyperhumic huh | | | | | | | | | | | | | |
| Hydragric hg | | | | | | | | **≤1.5** | | | | | |
| Hydric hy | | | | | | | | | | | | | |
| Hydrophobic hf | | | | | | | | | | | | | |
| Hyperalbic ha | | | | | | | | | | | | | |
| Hyperalic hl | | | | | | | | | | | | | |
| Hypercalcic hc | | | | | **≤1.5** | | | | | | | | |
| Hyperdystric hd | | | | **≤1.5** | | | | | | | | | |
| Hypereutric he | | | | | | | | | | | | | |
| Hypergypsic hp | | | | | **≤1.5** | | | | | | | | |
| Hyperochric ho | | | | | | | | | | | | | |
| Hypersalic hs | | **≤1.5** | | | | | | | | | | | |
| Hyperskeletic hk | | | | | | | | | | | **0** | | |
| Hypocalcic wc | | | | | | | | | | | | | |
| Hypogypsic wg | | | | | | | | | | | | | |
| Hypoluvic wl | | | | | | | | | | | | | |
| Hyposalic ws | | | | | | | | | | | | | |
| Hyposodic wn | | | | | | | | | | | | | |
| Irragric ir | | | | | | | | | | | | | |
| Lamellic ll | | | | | | | | | | | | | |
| Laxic la | | | | | | | | | | | | | |
| Leptic le | | | | | | | | | | | | | |
| Lignic lg | | | | | | | | | | | | | |
| Limnic lm | | | | | | | | | | | | | |
| Linic lc | | | | | | **≤1.5** | | | | | | | |
| Lithic li | | | | | | **0** | | | | | | | |
| Lixic lx | | | | | | | | | | | | | |
| Luvic lv | | | | | | | | | | | | | |
| Magnesic mg | | | | | | | | | | | | | |
| Manganiferric mf | | | | | | | | | | | | | |
| Mazic mz | | | | | | | | | | | | | |
| Melanic ml | | | | | | | | | | | | | |
| Mesotrophic ms | | | | | | | | | | | | | |
| Mollic mo | | | | | | | | | | | | | |
| Molliglossic mi | | | | | | | | | | | | | |
| Natric na | | | **≤1.5** | | | | | | | | | | |
| Nitic ni | | | | | | | | | | | | | |
| Novic nv | | | | | | | | | | | | | |
| Areninovic anv | | | | | | | | | | | | | |
| Nudilithic nt | | | | | | **0** | | | | **0** | | | |
| Ombric om | | | | | | | | | | | | | |
| Ornithic oc | | | | | | | | | | | | | |
| Ortsteinic os | | | | | | | | | | | | | |
| Oxyaquic oa | | | | | | | | | | | | | |
| Pachic ph | | | | | | **≥1** | **≥0.5** | **≥1** | **≥1** | **≥1** | | | |
| Pellic pe | | | | | | | | | | | | | |
| Petric pt | | | | | | **≤1.5** | | | | | | | |
| Endopetric ptn | | | | | | **≤1.5** | | | | | | | |
| Epipetric ptp | | | | | | **≤1** | | | | | | | |
| Petrocalcic pc | | | | | | **≤1.5** | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Petroduric pd | | | | | | ≤1.5 | | | | | | | |
| Petrogleyic py | | | | | | | | | | | | | |
| Petrogypsic pg | | | | | | ≤1.5 | | | | | | | |
| Petroplinthic pp | | | | | | ≤1.5 | | | | | | | |
| Petrosalic ps | | | | | | ≤1.5 | | | | | | | |
| Pisoplinthic px | | | | | | | | | | | | | |
| Placic pi | | | | | | | | | | | | | |
| Plaggic pa | | | | | | | | | | | | | |
| Plinthic pl | | | | | | | | | | | | | |
| Posic po | | | | | | | | | | | | | |
| Profondic pf | | | | | | | | | | | | | |
| Protic pr | | | | | | | | | | | | | |
| Puffic pu | | ≤1.5 | | | | | | | | | | | |
| Reductaquic ra | | | | | | ≤1 | | | | | | | |
| Reductic rd | | | | | | | | | | | | | |
| Regic rg | | | | | | | | | | | | | |
| Rendzic rz | | | | | | ≤1.5 | | | | | | | |
| Rheic rh | | | | | | | | | | | | | |
| Rhodic ro | | | | | | | | | | | | | |
| Rubic ru | | | | | | | | | | | | | |
| Ruptic rp | | | | | | | | | | | | | |
| Rustic rs | | | | | | | | | | | | | |
| Salic sz | | | | | | | | | | | | | |
| Sapric sa | | | | | | | | | | | | | |
| Silandic sn | | | | | | | | | | | | | |
| Thaptosilandic | | | | | | | | | | | | | |
| Siltic sl | | | | | | | | | | | | | |
| Endosiltic sln | | | | | | | | | | | | | |
| Episiltic slp | | | | | | | | | | | | | |
| Skeletic sk | | | | | | | | | | | ≤1 | | |
| Endoskeletic | | | | | | | | | | | ≤1.5 | | |
| Episkeletic | | | | | | | | | | | ≤1 | | |
| Sodic so | | | ≤1.5 | | | | | | | | | | |
| Endosodic | | | ≤1.5 | | | | | | | | | | |
| Solodic sc | | | | | | | | | | | | | |
| Sombric sm | | | | | | | | | | | | | |
| Spodic sd | | | | | | | | | | | | | |
| Spolic sp | | | | | | | | | | | | | |
| Stagnic st | | | | | | | | | | | | | |
| Endostagnic stn | | | | | | | | | | | | | |
| Epistagnic stc | | | | | | | | | | | | | |
| Subaquatic sq | | | | | | | | 0 | | | | | |
| Sulphatic su | | | | | | | | | | | | | |
| Takyric ty | | | | | | | ≤1 | ≤1 | | | | | |
| Technic te | | | | | | | | | | | | | |
| Tephric tf | | | | | | | | | | | | | |
| Terric tr | | | | | | | | | | | | | |
| Thaptandic ba | | | | | | | | | | | | | |
| Thaptovitric bv | | | | | | | | | | | | | |
| Thionic ti | | | | ≤1.5 | | | | | | | | | |
| Hyperthionic tih | | | | ≤1.5 | | | | | | | | | |
| Orthothionic tio | | | | | | | | | | | | | |
| Protothionic tip | | | | | | | | | | | | | |
| Thixotropic tp | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tidalic td | | | | | | | | **≤0.5** | | | | | |
| Toxic tx | **≤0.5** | | | | | | | | | | | | |
| Transportic tn | | | | | | | | | | | | | |
| Turbic tu | | | | | | | | | | | | | |
| Umbric um | | | | | | | | | | | | | |
| Umbriglossic ug | | | | | | | | | | | | | |
| Urbic ub | | | | | | | | | | | | | |
| Vermic vm | | | | | | | | | | | | | |
| Vertic vr | | | | | | | | | | | | | |
| Vetic vt | | | | | | | | | | | | | |
| Vitric vi | | | | | | | | | | | | | |
| Voronic vo | | | | | | | | | | | | | |
| Xanthic xa | | | | | | | | | | | | | |
| Yermic ye | | | | | | | | | | **0** | | | |

## Appendix 3: Orientation guides of indicator scoring based on vegetation in Central Europe (Indicators of salinity, alkalinity, acidity, drought and wetness, vegetation data adopted from Ellenberg et al, 2001).

Note: In some regions, specific plant lists of Ellenberg values are available, shey should be used. (For example: Australia: Victorian Resources online. 2007, England: ELLENBERG.S INDICATOR VALUES FOR BRITISH PLANTS, 2007).

**Table A3-1: Hazard indicator 2, Salinisation**

| Score | Characteristic | Orientation, check species of S >= 3 in list below |
|---|---|---|
| **2** | No salinisation | Most/dominant plants of S numbers =0 (not in list below), a few sub- dominant species may have S of 1-3 |
| **1.5** | Low salinisation | Most/dominant plants of S numbers of 1 or higher, S > 4 largely missing |
| **1** | Moderate salinisation | Most/dominant plants of S numbers > 3, some plants of S numbers of 3, species having S=0 largely missing |
| **0.5** | Strong salinisation | Most/dominant plants of S numbers > 5, some plants of S numbers of 3, species having S<=1 largely missing |
| **0** | Extreme salinisation | Most/dominant plants of S numbers > 8, some plants of S numbers of 3-8, species having S<=3 largely missing |

**Table A3-1.1: Plant list of S numbers > 0**

**The S number is listed along with F and R numbers to check the possible combination of salinity with drought (F <=3), waterlogging (F => 9), alkalinity (R =9) or acidity (R <=3).**

| GENUS | Species | S number | F number | R number |
|---|---|---|---|---|
| Achillea | millefolium | 1 | 4 | . |
| Agropyron | junceiforme | 7 | 6 = | 7 |
| Agropyron | pungens | 6 | 5 ~ | 7 |
| Alnus | glutinosa | 1 | 9 = | 6 |
| Alopecurus | bulbosus | 3 | 7 = | 7 |
| Alopecurus | geniculatus | 2 | 8 = | 7 |
| Alopecurus | utriculatus | 2 | 6 ~ | 8 |
| Althaea | officinalis | 2 | 7 = | 8 |
| Amaranthus | albus | 1 | 2 | . |
| Amaranthus | hybridus agg. | 1 | 4 | 7 |
| Amaranthus | powellii | 1 | 4 | 8 |
| Amaranthus | retroflexus | 1 | 4 | 7 |
| Ammocalamagrost | baltica | 1 | 4 | . |
| Ammophila | arenaria | 1 | 4 | 7 |
| Androsace | maxima | 1 | 4 | 7 |
| Angelica | archangelica | 1 | 9 = | . |

| GENUS | Species | S number | F number | R number |
|---|---|---|---|---|
| Anthoxanthum | odoratum | 1 | . | 5 |
| Apium | graveolens | 4 | 8 | 7 |
| Apium | nodiflorum | 1 | 10 | . |
| Apium | repens | 1 | 7 = | 7 |
| Armeria | maritima | 6 | 6 = | 5 |
| Artemisia | maritima | 5 | 5 = | . |
| Artemisia | rupestris | 3 | 7 | 8 |
| Aster | tripolium | 8 | . = | 7 |
| Atriplex | calotheca | 1 | 6 = | 7 |
| Atriplex | glabriuscula | 3 | 7 = | 7 |
| Atriplex | littoralis | 7 | . = | . |
| Atriplex | longipes | 5 | 6 ~ | . |
| Atriplex | oblongifolia | 1 | 4 | 6 |
| Atriplex | rosea | 1 | 5 | 7 |
| **B**aldellia | ranunculoides | 1 | 10 | . |
| Bassia | hirsuta | 7 | 8 = | 7 |
| Berula | erecta | 1 | 10 | 8 |
| Beta | vulgaris | 5 | 6 = | 7 |
| Blackstonia | acuminata | 1 | 7 ~ | 6 |
| Blysmus | compressus | 1 | 8 | 8 |
| Blysmus | rufus | 5 | 7 = | 7 |
| Bolboschoenus | maritimus | 2 | 10 | 8 |
| Brassica | oleracea | 3 | 5 | . |
| Bromus | hordeaceus agg. | 1 | . ~ | . |
| Bromus | hordeaceus ssp. | 1 | 4 | 4 |
| Bupleurum | tenuissimum | 3 | 7 ~ | 8 |
| **C**akile | maritima | 4 | 6 = | . |
| Calepina | irregularis | 1 | 3 | 8 |
| Callitriche | brutia | 1 | 10 | . |
| Callitriche | obtusangula | 1 | 11 | 7 |
| Callitriche | stagnalis | 1 | 10 | 6 |
| Carex | arenaria | 1 | 3 | 2 |
| Carex | distans | 5 | 6 ~ | 8 |
| Carex | extensa | 6 | 7 = | . |
| Carex | flacca | 1 | 6 ~ | 8 |
| Carex | hordeistichos | 2 | 7 = | 7 |
| Carex | nigra | 1 | 8 ~ | 3 |
| Carex | oederi | 2 | 9 | . |
| Carex | otrubae | 1 | 8 | 7 |
| Carex | panicea | 1 | 8 ~ | . |
| Carex | punctata | 1 | 7 = | 7 |
| Carex | scandinavica | 1 | 7 ~ | 7 |
| Carex | secalina | 2 | 7 | . |
| Carum | carvi | 1 | 5 | . |
| Catabrosa | aquatica | 1 | 9 = | 7 |
| Centaurium | littorale | 2 | 7 | 8 |
| Centaurium | pulchellum | 1 | . ~ | 9 |
| Cerastium | dubium | 2 | 8 = | 7 |
| Cerastium | holosteoides | 1 | 5 | . |
| Chenopodium | botryodes | 1 | 7 | 7 |
| Chenopodium | glaucum | 3 | 6 | . |
| Chenopodium | rubrum | 1 | 7 | 7 |
| Chenopodium | rubrum agg. | 1 | . | . |
| Cicendia | filiformis | 1 | 8 = | 3 |

| GENUS | Species | S number | F number | R number |
|---|---|---|---|---|
| Cirsium | arvense | 1 | . | . |
| Cochlearia | anglica | 8 | 8 = | 7 |
| Cochlearia | danica | 4 | 8 = | 8 |
| Cochlearia | officinalis agg | 2 | 7 = | 7 |
| Coronopus | squamatus | 1 | 6 ~ | 7 |
| Cotula | coronopifolia | 5 | 7 | 7 |
| Crambe | maritima | 3 | 6 = | 7 |
| Crepis | nicaeensis | 1 | 4 | 7 |
| **D**atura | stramonium | 1 | 4 | 7 |
| Deschampsia | wibeliana | 2 | 9 = | 8 |
| **E**leocharis | multicaulis | 1 | 10 | . |
| Eleocharis | parvula | 1 | 10 | 7 |
| Eleocharis | quinqueflora | 1 | 9 | 7 |
| Eleocharis | uniglumis | 5 | 9 = | 7 |
| Elymus | arenarius | 1 | 6 = | 7 |
| Epilobium | hirsutum | 1 | 8 = | 8 |
| Erysimum | repandum | 2 | 4 | 8 |
| Euphorbia | palustris | 1 | 8 ~ | 8 |
| **F**estuca | arundinacea | 2 | 7 ~ | 7 |
| **G**laucium | flavum | 2 | 6 | 8 |
| Glaux | maritima | 7 | 7 = | 7 |
| Gratiola | officinalis | 1 | 8 ~ | 7 |
| **H**alimione | pedunculata | 7 | 8 = | 7 |
| Halimione | portulacoides | 8 | 7 = | . |
| Holcus | lanatus | 1 | 6 | . |
| Honkenya | peploides | 5 | 6 | 7 |
| Hordeum | jubatum | 2 | 6 | 7 |
| Hordeum | marinum agg. | 6 | 8 = | 7 |
| Hordeum | secalinum | 4 | 6 | 6 |
| Hydrocotyle | vulgaris | 1 | 9 ~ | 3 |
| Hypochoeris | radicata | 1 | 5 | 4 |
| **I**nula | britannica | 2 | 7 = | 8 |
| Inula | salicina | 1 | 6 ~ | 9 |
| Iris | spuria | 2 | 7 | 8 |
| **J**uncus | ambiguus | 4 | 8 | 4 |
| Juncus | anceps | 3 | 7 | 7 |
| Juncus | articulatus | 1 | 9 | . |
| Juncus | balticus | 1 | 8 | 2 |
| Juncus | compressus | 1 | 8 = | 7 |
| Juncus | gerardii | 7 | . = | 7 |
| Juncus | inflexus | 1 | 7 ~ | 8 |
| Juncus | maritimus | 6 | 7 = | 7 |
| Juncus | subnodulosus | 2 | 8 | 9 |
| **L**actuca | saligna | 1 | 4 | 8 |
| Lactuca | tatarica | 2 | 6 ~ | 8 |
| Lathyrus | maritimus | 1 | 4 | 7 |
| Lavatera | thuringiaca | 1 | 5 | . |
| Lemna | gibba | 1 | 11 | 8 |
| Lemna | minor | 1 | 11 | . |
| Lemna | trisulca | 1 | 12 | 7 |
| Leontodon | saxatilis | 1 | 6 ~ | 6 |
| Lepidium | perfoliatum | 2 | 6 | 6 |
| Lepidium | latifolium | 4 | 5 ~ | 7 |
| Limonium | vulgare | 8 | 7 = | 7 |

| GENUS | Species | S number | F number | R number |
|---|---|---|---|---|
| Linum | catharticum | 1 | . | 7 |
| Littorella | uniflora | 1 | 10 | 7 |
| Lotus | tenuis | 4 | 7 ~ | 8 |
| Lycopus | exaltatus | 1 | 9 = | 8 |
| Lythrum | hyssopifolia | 2 | 7 = | 3 |
| Lythrum | salicaria | 1 | 8 ~ | 6 |
| **M**alva | pusilla | 1 | 4 | 5 |
| Melilotus | altissima | 2 | 7 ~ | 7 |
| Melilotus | dentata | 2 | 6 ~ | 7 |
| Melilotus | indica | 2 | 5 ~ | 7 |
| Mentha | pulegium | 1 | 7 = | 7 |
| Mentha | suaveolens | 1 | 8 = | 6 |
| **N**ajas | marina | 1 | 12 | 9 |
| **O**dontites | litoralis | 4 | 7 = | 7 |
| Odontites | rubra | 1 | 5 | 7 |
| Oenanthe | conioides | 2 | 10 | 7 |
| Oenanthe | lachenalii | 3 | 8 = | 8 |
| Oenanthe | silaifolia | 2 | 8 ~ | 7 |
| Oenothera | parviflora agg. | 1 | 3 | 7 |
| Oenothera | ammophila | 1 | 3 | 8 |
| Ononis | spinosa | 1 | 4 ~ | 7 |
| Ophioglossum | vulgatum | 1 | 7 | 7 |
| Orchis | palustris | 1 | 9 ~ | 8 |
| **P**arapholis | strigosa | 5 | 7 = | 7 |
| Phleum | arenarium | 1 | 3 | 7 |
| Plantago | coronopus | 4 | 7 = | 7 |
| Plantago | maritima | 7 | 7 = | 8 |
| Poa | annua | 1 | 6 | . |
| Poa | subcoerulea | 3 | 5 | 6 |
| Poa | trivialis | 1 | 7 | . |
| Podospermum | laciniatum | 1 | 3 ~ | 8 |
| Polygonum | aviculare agg. | 1 | 4 | . |
| Polygonum | oxyspermum | 1 | 7 = | 7 |
| Potamogeton | berchtoldii | 1 | 12 | 7 |
| Potamogeton | crispus | 1 | 12 | 7 |
| Potamogeton | pectinatus | 1 | 12 | 8 |
| Potamogeton | perfoliatus | 1 | 12 | 7 |
| Potamogeton | pusillus | 1 | 12 | 6 |
| Potamogeton | pusillus agg. | 1 | 12 | 6 |
| Potentilla | anserina | 1 | 6 ~ | . |
| Potentilla | supina | 2 | 8 = | 6 |
| Puccinellia | capillaris | 7 | 8 = | 7 |
| Puccinellia | distans | 7 | 6 ~ | 7 |
| Puccinellia | limosa | 6 | 7 | 7 |
| Puccinellia | maritima | 8 | 8 = | 7 |
| Pulicaria | vulgaris | 1 | 8 = | 6 |
| **R**anunculus | baudotii | 6 | 10 | 9 |
| Ranunculus | circinatus | 1 | 12 | 7 |
| Ranunculus | flammula | 1 | 9 ~ | 3 |
| Ranunculus | repens | 1 | 7 ~ | . |

| GENUS | Species | S number | F number | R number |
|---|---|---|---|---|
| Ranunculus | sardous | 1 | 8 = | . |
| Ranunculus | sceleratus | 2 | 9 = | 7 |
| Rumex | maritimus | 2 | 9 = | 8 |
| Rumex | stenophyllus | 2 | 7 = | 8 |
| Ruppia | cirrhosa | 9 | 12 | 8 |
| Ruppia | maritima | 9 | 10 = | 8 |
| **S**agina | maritima | 4 | 7 = | 8 |
| Sagina | nodosa | 2 | 8 ~ | 8 |
| Sagina | procumbens | 2 | 5 ~ | 7 |
| Salicornia | dolichostachya | 8 | 9 = | 7 |
| Salicornia | europaea | 9 | 8 = | 8 |
| Salicornia | fragilis | 7 | 7 = | 7 |
| Salicornia | ramosissima | 9 | 8 = | 8 |
| Salsola | kali | 6 | . = | 7 |
| Salsola | kali ssp. | 2 | 4 | 8 |
| Samolus | valerandi | 4 | 8 = | 7 |
| Schoenoplectus | americanus | 1 | 10 | 7 |
| Schoenoplectus | carinatus | 2 | 11 | 7 |
| Schoenoplectus | lacustris | 1 | 11 | 7 |
| Schoenoplectus | tabernaemontani | 3 | 10 | 9 |
| Schoenoplectus | triqueter | 2 | 10 | 7 |
| Schoenus | nigricans | 1 | 9 = | 9 |
| Sclerochloa | dura | 1 | 4 ~ | 8 |
| Scorzonera | parviflora | 5 | 7 | 8 |
| Sedum | acre | 1 | 2 | . |
| Senecio | vernalis | 1 | 4 | 7 |
| Sisymbrium | supinum | 1 | 7 = | 7 |
| Sonchus | arvensis | 1 | 5 ~ | 7 |
| Sonchus | asper | 1 | 6 | 7 |
| Sonchus | palustris | 1 | 8 ~ | 7 |
| Spartina | townsendii agg. | 8 | 9 = | 8 |
| Spergularia | media | 8 | 7 = | 7 |
| Spergularia | salina | 9 | 7 = | 9 |
| Spirodela | polyrhiza | 1 | 11 | 6 |
| Suaeda | maritima | 8 | 8 = | 7 |
| **T**araxacum | officinale agg. | 1 | 5 | . |
| Taraxacum | palustre agg. | 1 | 8 | 8 |
| Tetragonolobus | maritimus | 1 | . | 9 |
| Teucrium | scordium agg. | 1 | 8 = | 8 |
| Trifolium | fragiferum | 4 | 7 = | 8 |
| Trifolium | repens | 1 | 5 | 6 |
| Trifolium | resupinatum | 2 | 6 ~ | 7 |
| Trifolium | striatum | 1 | 3 | 2 |
| Triglochin | maritimum | 8 | 7 = | . |
| Triglochin | palustre | 3 | 9 = | . |
| Tripleurospermum | maritimum | 6 | 6 = | 7 |
| Typha | angustifolia | 1 | 10 | 7 |
| Typha | latifolia | 1 | 10 | 7 |
| **V**erbascum | blattaria | 1 | 3 | 7 |
| Vicia | cracca | 1 | 5 | . |
| Vicia | lutea | 1 | 4 | 7 |
| Viola | tricolor ssp. | 1 | 3 | 6 |
| **X**anthium | strumarium | 1 | 5 | 7 |
| **Z**annichellia | palustris | 5 | 12 | 8 |
| Zostera | marina | 3 | 12 | 7 |
| Zostera | noltii | 3 | 12 | 7 |

**Table A3-1.2: Legend S number acc. to Ellenberg:**

| Value | Description | Explanation |
|---|---|---|
| **1** | Salt tolerant | Plant mainly on soils free of salts or low-salt soils, partly on slightly salty soils (0-0.1% $Cl^-$) |
| **2** | oligohyalin (I) | Mainly on soils of very low chloride content (0,05-0,3% $Cl^-$) |
| **3** | β-mesohyalin (II) | Mainly on soils of low chloride content (0.3-0.5% $Cl^-$) |
| **4** | α/β-mesohyalin (II/III) | Mainly on soils of low to moderate chloride content (0.5-0.7% $Cl^-$) |
| **5** | α-mesohyalin (III) | Mainly on soils of moderate chloride content (0.7-0.9% $Cl^-$) |
| **6** | α-meso-/polyhyalin (III/IV) | On soils of moderate to high chloride content (0.9-1.2% $Cl^-$) |
| **7** | polyhyalin (IV) | On soils of high chloride content (1.2-1.6% $Cl^-$) |
| **8** | euhalin (IV/V und V) | On soils of very high chloride content (1.6-2.3% $Cl^-$) |
| **9** | euhalin bis hypersalin (V/VI) | On soils of very high, in dry periods extremely high chloride content (>2.3% $Cl^-$) |

**Table A3-2: Hazard indicator 3, Sodification [1)]**

| Score | Characteristic | Extremely rought orientation, check species of R= 9 in list below [1)] |
|---|---|---|
| **2** | No to slight sodification | Most/dominant plants of R numbers < 9 (not in list below) |
| **1.5** | Low to moderate sodification | |
| **1** | Moderate to high sodification | Many species of R numbers of 9 |
| **0.5** | High to very high sodification | |
| **0** | Extreme sodification | Most/dominant plants of R numbers of 9 |

[1)] Plants in the list below characterize either the presence of lime than of sodium. They are thus no indicators of sodification, but give a hint for a possible high pH which could be associated with sodification

***Table A3-2.1: Plant list of R numbers of 9***

| GENUS | Species | R number | GENUS | Species | R number |
|---|---|---|---|---|---|
| Achillea | clusiana | 9 | Himantoglossum | hircinum | 9 |
| Acinos | alpinus | 9 | Horminum | pyrenaicum | 9 |
| Adonis | flammea | 9 | Hornungia | petraea | 9 |
| Aethionema | saxatile | 9 | Hutchinsia | alpina | 9 |
| Aethusa | cynapium ssp. | 9 | Hydrilla | verticillata | 9 |
| Ajuga | chamaepitys | 9 | Hypericum | elegans | 9 |

| GENUS | Species | R number |
|---|---|---|
| Alchemilla | hoppeana | 9 |
| Allium | suaveolens | 9 |
| Amaranthus | graecizans | 9 |
| Anacamptis | pyramidalis | 9 |
| Anagallis | foemina | 9 |
| Androsace | chamaejasme | 9 |
| Androsace | hausmannii | 9 |
| Androsace | lactea | 9 |
| Anthemis | austriaca | 9 |
| Aquilegia | einseliana | 9 |
| Arabis | alpina | 9 |
| Arabis | caerulea | 9 |
| Arabis | ciliata | 9 |
| Arabis | pumila | 9 |
| Arabis | soyeri | 9 |
| Asperula | arvensis | 9 |
| Asperula | tinctoria | 9 |
| Asplenium | seelosii | 9 |
| Aster | amellus | 9 |
| Astragalus | cicer | 9 |
| Astragalus | frigidus | 9 |
| Astragalus | danicus | 9 |
| Astragalus | exscapus | 9 |
| Astragalus | onobrychis | 9 |
| Athamantha | cretensis | 9 |
| **B**ifora | radians | 9 |
| Blackstonia | perfoliata | 9 |
| Bunium | bulbocastanum | 9 |
| Bupleurum | falcatum | 9 |
| Bupleurum | longifolium | 9 |
| Bupleurum | ranunculoides | 9 |
| Bupleurum | rotundifolium | 9 |
| **C**alamagrostis | pseudophragmite | 9 |
| Calamintha | nepeta agg. | 9 |
| Carduus | crassifolius | 9 |
| Carex | appropinquata | 9 |
| Carex | brachystachys | 9 |
| Carex | firma | 9 |
| Carex | lepidocarpa | 9 |
| Carex | mucronata | 9 |
| Carex | ornithopoda | 9 |
| Carex | ornithopoides | 9 |
| Carex | tomentosa | 9 |
| Caucalis | platycarpos | 9 |
| Centaurium | pulchellum | 9 |
| Cerastium | latifolium | 9 |
| Chaerophyllum | aureum | 9 |
| Chamorchis | alpina | 9 |
| Chondrilla | chondrilloides | 9 |
| Cirsium | eriophorum | 9 |
| Cladium | mariscus | 9 |
| Conringia | orientalis | 9 |
| Coronilla | coronata | 9 |
| Coronilla | emerus | 9 |

| GENUS | Species | R number |
|---|---|---|
| **I**beris | intermedia | 9 |
| Inula | salicina | 9 |
| Inula | spiraeifolia | 9 |
| Iris | sambucina | 9 |
| **J**uncus | subnodulosus | 9 |
| **K**ernera | saxatilis | 9 |
| Koeleria | vallesiana | 9 |
| **L**aser | trilobum | 9 |
| Laserpitium | latifolium | 9 |
| Laserpitium | siler | 9 |
| Lathyrus | bauhinii | 9 |
| Lathyrus | latifolius | 9 |
| Lathyrus | pannonicus | 9 |
| Leontodon | incanus | 9 |
| Leontodon | montanus | 9 |
| Leucanthemum | halleri | 9 |
| Linum | leonii | 9 |
| Linum | perenne ssp. | 9 |
| Linum | tenuifolium | 9 |
| Liparis | loeselii | 9 |
| **M**edicago | falcata | 9 |
| Mentha | longifolia | 9 |
| Micropus | erectus | 9 |
| Minuartia | austriaca | 9 |
| Moehringia | muscosa | 9 |
| Myagrum | perfoliatum | 9 |
| Myosotis | alpestris | 9 |
| Myosotis | rehsteineri | 9 |
| Myriophyllum | spicatum | 9 |
| **N**ajas | intermedia | 9 |
| Najas | marina | 9 |
| Nigella | arvensis | 9 |
| Nigritella | miniata | 9 |
| Nonea | pulla | 9 |
| **O**dontites | lutea | 9 |
| Onobrychis | arenaria | 9 |
| Onobrychis | montana | 9 |
| Ophrys | apifera | 9 |
| Ophrys | holoserica | 9 |
| Ophrys | insectifera | 9 |
| Ophrys | sphecodes agg. | 9 |
| Orchis | militaris | 9 |
| Orchis | tridentata | 9 |
| Orlaya | grandiflora | 9 |
| Orobanche | alba | 9 |
| Orobanche | caryophyllacea | 9 |
| Orobanche | flava | 9 |
| Orobanche | teucrii | 9 |
| Oxytropis | jacquinii | 9 |
| **P**apaver | sendtneri | 9 |
| Pedicularis | oederi | 9 |
| Pedicularis | rostrato-capita | 9 |
| Pedicularis | rostrato-spicat | 9 |
| Petrocallis | pyrenaica | 9 |

| GENUS | Species | R number |
|---|---|---|
| Coronilla | vaginalis | 9 |
| Coronilla | varia | 9 |
| Corydalis | lutea | 9 |
| Cotoneaster | tomentosus | 9 |
| Crepis | kerneri | 9 |
| Crepis | praemorsa | 9 |
| Crepis | terglouensis | 9 |
| Cyclamen | purpurascens | 9 |
| Cystopteris | dickieana | 9 |
| Cystopteris | montana | 9 |
| Cystopteris | sudetica | 9 |
| **D**oronicum | grandiflorum | 9 |
| Dorycnium | germanicum | 9 |
| Dorycnium | herbaceum | 9 |
| Draba | aizoides | 9 |
| Draba | ladina | 9 |
| Draba | sauteri | 9 |
| Draba | tomentosa | 9 |
| Dryopteris | villarii | 9 |
| **E**pilobium | dodonaei | 9 |
| Epipactis | leptochila | 9 |
| Erigeron | acris ssp. | 9 |
| Erigeron | neglectus | 9 |
| Erigeron | polymorphus | 9 |
| Erophila | spathulata | 9 |
| Erysimum | cheiri | 9 |
| Erysimum | hieraciifolium | 9 |
| Euphorbia | verrucosa | 9 |
| Euphrasia | cuspidata | 9 |
| **F**alcaria | vulgaris | 9 |
| Festuca | alpina | 9 |
| Festuca | norica | 9 |
| Festuca | stenantha | 9 |
| Fumana | procumbens | 9 |
| **G**alium | glaucum | 9 |
| Galium | megalospermum | 9 |
| Galium | truniacum | 9 |
| Gentiana | clusii | 9 |
| Gentiana | utriculosa | 9 |
| Gentianella | aspera | 9 |
| Glaucium | corniculatum | 9 |
| Globularia | cordifolia | 9 |
| Globularia | punctata | 9 |
| Gymnadenia | odoratissima | 9 |
| Gypsophila | repens | 9 |
| **H**elianthemum | alpestre agg. | 9 |
| Helianthemum | canum | 9 |
| Helianthemum | grandiflorum ss | 9 |
| Helianthemum | ovatum | 9 |
| Helictotrichon | parlatorei | 9 |
| Hieracium | bupleuroides | 9 |
| Hieracium | glaucum | 9 |
| Hieracium | morisianum | 9 |
| Hieracium | scorzonerifoliu | 9 |
| Hieracium | villosum | 9 |

| GENUS | Species | R number |
|---|---|---|
| Peucedanum | alsaticum | 9 |
| Pinus | nigra | 9 |
| Poa | compressa | 9 |
| Polygala | amarella | 9 |
| Polygala | calcarea | 9 |
| Potentilla | brauneana | 9 |
| Potentilla | heptaphylla | 9 |
| Primula | farinosa | 9 |
| Prunella | laciniata | 9 |
| Pulsatilla | grandis | 9 |
| **R**anunculus | baudotii | 9 |
| Ranunculus | hybridus | 9 |
| Ranunculus | parnassifolius | 9 |
| Rapistrum | perenne | 9 |
| Reseda | luteola | 9 |
| Rhamnus | pumilus | 9 |
| Rhamnus | saxatilis | 9 |
| Rorippa | anceps | 9 |
| Rumex | palustris | 9 |
| **S**alix | reticulata | 9 |
| Salix | serpillifolia | 9 |
| Salvia | nemorosa | 9 |
| Saponaria | ocymoides | 9 |
| Saxifraga | aphylla | 9 |
| Saxifraga | burserana | 9 |
| Saxifraga | caesia | 9 |
| Saxifraga | mutata | 9 |
| Schoenoplectus | tabernaemontani | 9 |
| Schoenus | nigricans | 9 |
| Seseli | annuum | 9 |
| Seseli | hippomarathrum | 9 |
| Sesleria | varia | 9 |
| Silene | pusilla | 9 |
| Spergularia | salina | 9 |
| Spiranthes | aestivalis | 9 |
| Stachys | alpina | 9 |
| Stachys | recta | 9 |
| **T**etragonolobus | maritimus | 9 |
| Teucrium | montanum | 9 |
| Thesium | rostratum | 9 |
| Thlaspi | rotundifolium | 9 |
| Thlaspi | montanum | 9 |
| Torilis | arvensis | 9 |
| Trifolium | scabrum | 9 |
| Trisetum | distichophyllum | 9 |
| Turgenia | latifolia | 9 |
| **V**accaria | hispanica | 9 |
| Valeriana | montana | 9 |
| Valeriana | pratensis | 9 |
| Valeriana | supina | 9 |
| Valeriana | saxatilis | 9 |
| Verbascum | pulverulentum | 9 |
| Veronica | austriaca | 9 |
| Veronica | fruticulosa | 9 |
| Viola | cenisia | 9 |

**Table A3-2.2: Legend R number acc. to Ellenberg**

| Value | Description | Explanation |
|---|---|---|
| 9 | Indicator of alkalinity and lime | Only on soils rich in lime (or high pH) |

**Table A3-3: Hazard indicator 4, Acidification**

| Score | Characteristic | Orientation, check species of R <= 3 in list below |
|---|---|---|
| 2 | No significant acidification | Most/dominant plants of R numbers > 3 (not in list below), a few sub- dominant species may have R of 1-3 |
| 1.5 | Low to moderate acidification | |
| 1 | Moderate to high acidification | Most/dominant plants of R numbers of 1-3, a few sub-dominant species may have R > 3 |
| 0.5 | High to very high acidification | |
| 0 | Extreme acidification | Most/dominant plants of R numbers of 1, some plants of R numbers of 2-3, species having R > 3 largely missing |

***Table A3-3.1: Plant list of R numbers <=3***

| GENUS | Species | R number | GENUS | Species | R number |
|---|---|---|---|---|---|
| Achillea | moschata | 3 | Juncus | bufonius agg. | 3 |
| Agrostis | canina | 3 | Juncus | effusus | 3 |
| Agrostis | rupestris | 2 | Juncus | jacquinii | 2 |
| Agrostis | stricta | 2 | Juncus | squarrosus | 1 |
| Aira | praecox | 2 | Kalmia | angustifolia | 1 |
| Ajuga | pyramidalis | 1 | Koeleria | hirsuta | 3 |
| Alchemilla | alpina | 2 | Laserpitium | halleri | 3 |
| Alchemilla | pentaphyllea | 3 | Lathyrus | linifolius | 3 |
| Amelanchier | lamarckii | 3 | Ledum | palustre | 2 |
| Andromeda | polifolia | 1 | Leontodon | helveticus | 3 |
| Androsace | alpina | 2 | Ligusticum | mutellinoides | 3 |
| Androsace | obtusifolia | 1 | Linnaea | borealis | 2 |
| Antennaria | dioica | 3 | Listera | cordata | 2 |
| Anthoxanthum | alpinum | 2 | Loiseleuria | procumbens | 3 |
| Anthoxanthum | puelii | 2 | Lonicera | caerulea | 2 |
| Armeria | alpina | 2 | Lonicera | periclymenum | 3 |
| Arnica | montana | 3 | Luzula | campestris | 3 |
| Arnoseris | minima | 3 | Luzula | luzuloides | 3 |
| Asplenium | adiantum-nigrum | 2 | Luzula | nivea | 3 |
| Asplenium | alternifolium | 3 | Luzula | pallescens | 3 |

| GENUS | Species | R number |
|---|---|---|
| Asplenium | septentrionale | 2 |
| Avenella | flexuosa | 2 |
| Avenochloa | versicolor | 3 |
| **B**etula | carpatica | 1 |
| Betula | nana | 1 |
| Betula | pubescens | 3 |
| Blechnum | spicant | 2 |
| Botrychium | matricariifoliu | 3 |
| Botrychium | simplex | 1 |
| Bupleurum | stellatum | 3 |
| **C**alamagrostis | villosa | 2 |
| Calluna | vulgaris | 1 |
| Campanula | barbata | 1 |
| Cardamine | matthioli | 3 |
| Cardamine | resedifolia | 3 |
| Cardaminopsis | halleri | 3 |
| Carex | arenaria | 2 |
| Carex | bigelowii | 1 |
| Carex | binervis | 1 |
| Carex | brunnescens | 3 |
| Carex | curvula | 2 |
| Carex | echinata | 3 |
| Carex | fuliginosa | 2 |
| Carex | leporina | 3 |
| Carex | ligerica | 2 |
| Carex | limosa | 2 |
| Carex | nigra | 3 |
| Carex | pauciflora | 1 |
| Carex | paupercula | 3 |
| Carex | pilulifera | 3 |
| Carex | pseudobrizoides | 2 |
| Carex | rostrata | 3 |
| Carex | trinervis | 3 |
| Carlina | acaulis ssp. | 3 |
| Centaurea | nigra | 3 |
| Cerastium | pedunculatum | 3 |
| Chamaedaphne | calyculata | 3 |
| Cicendia | filiformis | 3 |
| Clematis | alpina | 3 |
| Coleanthus | subtilis | 3 |
| Corallorhiza | trifida | 3 |
| Cornus | suecica | 2 |
| Corydalis | claviculata | 3 |
| Corynephorus | canescens | 3 |
| Crepis | conyzifolia | 2 |
| Cryptogramma | crispa | 3 |
| Cytisus | scoparius | 3 |
| **D**actylorhiza | maculata ssp. | 2 |
| Dactylorhiza | majalis ssp. | 3 |
| Dactylorhiza | sphagnicola | 3 |
| Danthonia | decumbens | 3 |
| Deschampsia | setacea | 2 |

| GENUS | Species | R number |
|---|---|---|
| Luzula | sudetica | 3 |
| Luzula | sylvatica ssp. | 2 |
| Lycopodiella | inundata | 3 |
| Lycopodium | annotinum | 3 |
| Lycopodium | clavatum | 2 |
| Lythrum | hyssopifolia | 3 |
| **M**aianthemum | bifolium | 3 |
| Melampyrum | pratense | 3 |
| Melampyrum | pratense ssp. | 3 |
| Melampyrum | sylvaticum | 2 |
| Meum | athamanticum | 3 |
| Minuartia | recurva | 3 |
| Minuartia | stricta | 2 |
| Monotropa | hypopitys agg. | 3 |
| Montia | fontana ssp. | 3 |
| Myrica | gale | 3 |
| **N**ardus | stricta | 2 |
| Narthecium | ossifragum | 2 |
| **O**reochloa | disticha | 1 |
| Ornithopus | perpusillus | 2 |
| Orobanche | rapum-genistae | 3 |
| Oxyria | digyna | 3 |
| **P**edicularis | sylvatica | 1 |
| Peplis | portula | 3 |
| Phyteuma | betonicifolium | 2 |
| Phyteuma | hemisphaericum | 3 |
| Pinus | rotundata | 2 |
| Plantago | alpina | 3 |
| Poa | chaixii | 3 |
| Poa | laxa | 3 |
| Polygala | serpyllifolia | 2 |
| Polygala | vulgaris | 3 |
| Polypodium | vulgare agg. | 2 |
| Potamogeton | polygonifolius | 3 |
| Potentilla | argentea agg. | 3 |
| Potentilla | aurea | 3 |
| Potentilla | collina | 2 |
| Potentilla | frigida | 2 |
| Potentilla | palustris | 3 |
| Potentilla | rhenana | 2 |
| Primula | glutinosa | 2 |
| Primula | hirsuta | 3 |
| Primula | integrifolia | 3 |
| Primula | minima | 1 |
| Pseudorchis | albida | 2 |
| Pteridium | aquilinum | 3 |
| Pulsatilla | alba | 2 |
| Pulsatilla | apiifolia | 3 |
| Pyrola | minor | 3 |
| **R**adiola | linoides | 3 |
| Ranunculus | flammula | 3 |
| Ranunculus | glacialis | 3 |

| GENUS | Species | R number |
|---|---|---|
| Dianthus | deltoides | 3 |
| Dianthus | seguieri | 3 |
| Digitalis | purpurea | 3 |
| Digitaria | ischaemum | 2 |
| Diphasium | alpinum | 2 |
| Diphasium | complanatum | 1 |
| Diphasium | issleri | 1 |
| Diphasium | tristachyum | 1 |
| Diphasium | zeilleri | 1 |
| Drosera | anglica | 3 |
| Drosera | intermedia | 2 |
| Drosera | obovata | 2 |
| Drosera | rotundifolia | 1 |
| Dryopteris | expansa | 2 |
| **E**latine | hexandra | 3 |
| Elatine | hydropiper | 2 |
| Epilobium | collinum | 2 |
| Epilobium | lanceolatum | 3 |
| Epilobium | nutans | 3 |
| Epilobium | palustre | 3 |
| Erica | cinerea | 2 |
| Erica | tetralix | 1 |
| Eriophorum | vaginatum | 2 |
| Eritrichum | nanum | 2 |
| Euphrasia | drosocalix | 2 |
| Euphrasia | frigida | 3 |
| Euphrasia | micrantha | 2 |
| Euphrasia | minima | 2 |
| **F**estuca | halleri | 1 |
| Festuca | nigrescens | 3 |
| Festuca | ovina | 3 |
| Festuca | supina | 2 |
| Festuca | tenuifolia | 3 |
| Festuca | varia | 3 |
| **G**aleopsis | segetum | 3 |
| Galium | harcynicum | 2 |
| Genista | anglica | 2 |
| Genista | germanica | 2 |
| Genista | pilosa | 2 |
| Gentiana | acaulis | 2 |
| Gentiana | pannonica | 1 |
| Gentiana | punctata | 2 |
| Gentiana | purpurea | 3 |
| Geum | montanum | 2 |
| Geum | reptans | 2 |
| Gnaphalium | supinum | 3 |
| Gypsophila | muralis | 3 |
| **H**ammarbya | paludosa | 2 |
| Hieracium | alpinum | 1 |
| Hieracium | fuscum | 3 |
| Hieracium | glaciale | 1 |
| Hieracium | glanduliferum | 1 |
| Hieracium | glaucinum | 3 |

| GENUS | Species | R number |
|---|---|---|
| Ranunculus | grenieranus | 2 |
| Ranunculus | hederaceus | 3 |
| Ranunculus | pygmaeus | 3 |
| Rhododendron | ferrugineum | 2 |
| Rhynchospora | alba | 3 |
| Rhynchospora | fusca | 1 |
| Rubus | chamaemorus | 2 |
| Rumex | acetosella | 2 |
| Rumex | acetosella agg. | 2 |
| Rumex | tenuifolius | 2 |
| **S**alix | herbacea | 3 |
| Saxifraga | aspera | 3 |
| Saxifraga | bryoides | 3 |
| Saxifraga | cotyledon | 3 |
| Saxifraga | cuneifolia | 3 |
| Saxifraga | exarata agg. | 2 |
| Saxifraga | seguieri | 3 |
| Scheuchzeria | palustris | 3 |
| Scleranthus | annuus | 2 |
| Scleranthus | polycarpos | 3 |
| Scutellaria | minor | 2 |
| Sempervivum | arachnoideum | 2 |
| Sempervivum | montanum | 2 |
| Senecio | incanus | 1 |
| Sibbaldia | procumbens | 2 |
| Silene | exscapa | 2 |
| Silene | rupestris | 3 |
| Soldanella | montana | 2 |
| Soldanella | pusilla | 2 |
| Solidago | virgaurea ssp. | 2 |
| Sparganium | angustifolium | 3 |
| Spergula | arvensis | 3 |
| Spergularia | rubra | 3 |
| Stachys | arvensis | 3 |
| Stellaria | longifolia | 2 |
| Subularia | aquatica | 2 |
| **T**anacetum | alpinum | 2 |
| Teesdalia | nudicaulis | 1 |
| Teucrium | scorodonia | 2 |
| Thelypteris | limbosperma | 3 |
| Thesium | ebracteatum | 2 |
| Trichophorum | alpinum | 2 |
| Trichophorum | cespitosum | 1 |
| Trichophorum | cespitosum agg. | 1 |
| Trichophorum | germanicum | 1 |
| Trientalis | europaea | 3 |
| Trifolium | alpinum | 2 |
| Trifolium | arvense | 2 |
| Trifolium | spadiceum | 3 |
| Trifolium | striatum | 2 |
| **U**lex | europaeus | 3 |
| Utricularia | bremii | 3 |
| Utricularia | ochroleuca | 3 |

| GENUS | Species | R number |
|---|---|---|
| Hieracium | laevigatum | 2 |
| Hieracium | pallidum | 2 |
| Holcus | mollis | 2 |
| Huperzia | selago | 3 |
| Hydrocotyle | vulgaris | 3 |
| Hymenophyllum | tunbrigense | 3 |
| Hypericum | elodes | 2 |
| Hypericum | maculatum | 3 |
| Hypericum | pulchrum | 3 |
| Hypochoeris | glabra | 3 |
| Illecebrum | verticillatum | 3 |
| Isolepis | fluitans | 3 |
| Jasione | laevis | 3 |
| Jasione | montana | 3 |
| Juncus | balticus | 2 |

| GENUS | Species | R number |
|---|---|---|
| Vaccinium | gaultherioides | 3 |
| Vaccinium | macrocarpon | 1 |
| Vaccinium | microcarpum | 1 |
| Vaccinium | myrtillus | 2 |
| Vaccinium | uliginosum | 1 |
| Vaccinium | vitis-idaea | 2 |
| Veronica | bellidioides | 1 |
| Veronica | officinalis | 3 |
| Veronica | scutellata | 3 |
| Vicia | lathyroides | 3 |
| Viola | canina | 3 |
| Viola | epipsila | 3 |
| Viola | palustris | 2 |
| Woodsia | ilvensis | 3 |

**Table A3-3.2: Legend R number acc. to Ellenberg**

| Value | Description | Explanation |
|---|---|---|
| 1 | Strong acidity | Plant ever on acid soils, never on weak acid to alkaline soils |
| 2 | | |
| 3 | Acidity | Plant mainly on acid soils, only exceptional on neutral soils |

**Table A3-4: Hazard indicator 7, Drought**

| Score | Characteristic | Orientation, check species of F <= 3 in list below |
|---|---|---|
| 2 | No risk of drought | All plants of F numbers > 3 (not in list below), a few sub-dominant species may have 3 |
| 1.5 | Low risk of drought | |
| 1 | Medium risk of drought | Most plants of F numbers > 3 (not in list below), some plants of F numbers of 3, species having 2 and 1 are missing |
| 0.5 | High risk of drought | |
| 0 | Extreme high risk of drought | Most plants of F numbers 2 or 1, some have 3, some sub-dominant species have 4 or higher |

**Table A3-4.1: Plant list of F numbers <=3**

| GENUS | SPECIES | F number |
|---|---|---|
| Acer | monspessulanum | 3 |
| Achillea | collina | 2 |
| Achillea | pannonica | 3 |
| Achillea | setacea | 2 |
| Achnatherum | calamagrostis | 3 |
| Acinos | arvensis | 2 |
| Adonis | aestivalis | 3 |
| Adonis | flammea | 3 |
| Adonis | vernalis | 3 |
| Agropyron | intermedium | 3 ~ |
| Agrostis | stricta | 2 |
| Aira | caryophyllea | 2 |
| Aira | praecox | 2 |
| Ajuga | genevensis | 3 |
| Allium | carinatum | 3 ~ |
| Allium | montanum | 2 |
| Allium | oleraceum | 3 |
| Allium | pulchellum | 2 |
| Allium | sphaerocephalon | 3 |
| Allium | strictum | 2 |
| Alyssum | alyssoides | 3 |
| Alyssum | montanum | 2 |
| Amaranthus | albus | 2 |
| Amaranthus | blitoides | 3 |
| Amaranthus | graecizans | 3 |
| Ambrosia | psilostachya | 3 |
| Amelanchier | ovalis | 3 |
| Anacamptis | pyramidalis | 3 |
| Anchusa | officinalis | 3 |
| Androsace | elongata | 2 |
| Androsace | hausmannii | 3 ~ |
| Androsace | septentrionalis | 2 |
| Anemone | sylvestris | 3 |
| Anthemis | austriaca | 3 |
| Anthemis | ruthenica | 3 |
| Anthemis | tinctoria | 3 |
| Anthericum | liliago | 3 |
| Anthericum | ramosum | 3 |
| Anthyllis | vulneraria | 3 |
| Apera | interrupta | 2 |
| Arabis | auriculata | 3 |
| Arabis | brassica | 3 |
| Arabis | glabra | 3 |
| Arabis | turrita | 3 |
| Arctostaphylos | uva-ursi | 3 |
| Armeria | alliacea | 3 |
| Armeria | elongata | 3 |
| Armeria | elongata ssp | 3 |
| Armeria | halleri | 3 |
| Artemisia | campestris | 2 |
| Artemisia | mutellina | 3 |
| Lepidium | neglectum | 3 |
| Linum | austriacum | 3 |
| Linum | leonii | 3 |
| Linum | perenne | 3 |
| Linum | tenuifolium | 2 |
| Lonicera | etrusca | 3 |
| Lychnis | viscaria | 3 |
| Medicago | falcata | 3 |
| Medicago | minima | 3 |
| Medicago | nigra | 3 |
| Melampyrum | cristatum | 3 ~ |
| Melica | transsilvanica | 3 |
| Melica | ciliata | 2 |
| Melilotus | alba | 3 |
| Melilotus | officinalis | 3 |
| Mibora | minima | 3 |
| Micropus | erectus | 2 |
| Minuartia | cherlerioides | 3 |
| Minuartia | fastigiata | 2 |
| Minuartia | hybrida | 3 |
| Minuartia | rupestris | 3 |
| Minuartia | setacea | 2 |
| Minuartia | verna | 3 |
| Minuartia | viscosa | 3 |
| Moenchia | erecta | 2 |
| Muscari | comosum | 3 |
| Muscari | neglectum | 3 |
| Muscari | racemosum | 3 |
| Muscari | tenuiflorum | 3 |
| Myosotis | ramosissima | 2 |
| Myosotis | stricta | 3 |
| Nardurus | halleri | 2 |
| Nepeta | pannonica | 2 |
| Nigella | arvensis | 3 |
| Nonea | pulla | 3 |
| Odontites | lutea | 3 |
| Odontites | viscosa | 3 |
| Oenothera | ammophila | 3 |
| Oenothera | parviflora agg. | 3 |
| Onobrychis | arenaria | 2 |
| Onobrychis | viciifolia | 3 |
| Ononis | natrix | 3 |
| Onosma | arenarium | 3 |
| Orchis | militaris | 3 |
| Orchis | simia | 3 |
| Orchis | tridentata | 3 |
| Origanum | vulgare | 3 |
| Orlaya | grandiflora | 3 |
| Ornithogalum | kochii | 2 |
| Ornithopus | perpusillus | 3 |
| Orobanche | alba | 3 |

| GENUS | SPECIES | F number |
|---|---|---|
| Artemisia | pontica | 3 |
| Asparagus | officinalis | 3 ~ |
| Asperula | cynanchica | 3 |
| Asplenium | ruta-muraria | 3 |
| Asplenium | seelosii | 3 |
| Asplenium | septentrionale | 3 |
| Aster | linosyris | 2 |
| Astragalus | arenarius | 2 |
| Astragalus | danicus | 3 ~ |
| Astragalus | exscapus | 3 |
| Astragalus | onobrychis | 2 |
| Atriplex | tatarica | 3 |
| Aurinia | saxatilis | 2 |
| Avenochloa | pratensis | 3 ~ |
| **B**erteroa | incana | 3 |
| Bifora | radians | 3 |
| Bothriochloa | ischaemum | 3 |
| Bromus | erectus | 3 |
| Bromus | squarrosus | 3 |
| Bromus | tectorum | 3 |
| Bupleurum | falcatum | 3 |
| Bupleurum | rotundifolium | 3 |
| **C**alamintha | nepeta agg. | 3 |
| Calepina | irregularis | 3 |
| Campanula | bononiensis | 3 |
| Cardaminopsis | petraea | 3 |
| Cardaria | draba | 3 |
| Carex | arenaria | 3 |
| Carex | hallerana | 3 |
| Carex | humilis | 2 |
| Carex | ligerica | 3 |
| Carex | michelii | 3 |
| Carex | mucronata | 3 |
| Carex | ornithopoda | 3 |
| Carex | praecox agg. | 3 ~ |
| Carex | supina | 2 |
| Catapodium | rigidum | 2 |
| Centaurea | diffusa | 3 |
| Centaurea | jacea ssp. | 3 |
| Centaurea | paniculata agg. | 2 |
| Centaurea | scabiosa | 3 |
| Cephalanthera | rubra | 3 |
| Cerastium | arvense ssp. | 3 |
| Cerastium | brachypetalum a | 3 |
| Cerastium | pumilum agg. | 2 |
| Cerastium | semidecandrum | 3 |
| Ceterach | officinarum | 3 |
| Chamaecytisus | supinus | 3 |
| Chondrilla | juncea | 3 |
| Cirsium | acaule | 3 |
| Clematis | recta | 3 ~ |
| Colutea | arborescens | 3 |
| Conringia | orientalis | 3 |
| Corispermum | hyssopifolium a | 3 |

| GENUS | SPECIES | F number |
|---|---|---|
| Orobanche | alsatica | 3 |
| Orobanche | amethystea | 1 |
| Orobanche | arenaria | 3 |
| Orobanche | bartlingii | 3 |
| Orobanche | caryophyllacea | 3 |
| Orobanche | coerulescens | 2 |
| Orobanche | gracilis | 3 |
| Orobanche | lutea | 3 |
| Orobanche | mayeri | 3 |
| Orobanche | teucrii | 2 |
| Oxytropis | pilosa | 1 |
| **P**etrorhagia | prolifera | 3 |
| Petrorhagia | saxifraga | 2 |
| Peucedanum | cervaria | 3 |
| Peucedanum | oreoselinum | 3 |
| Phleum | arenarium | 3 |
| Phleum | phleoides | 3 |
| Phyteuma | tenerum | 2 |
| Pimpinella | nigra | 2 |
| Pimpinella | saxifraga | 3 |
| Pinus | nigra | 3 |
| Poa | badensis | 3 |
| Poa | bulbosa | 3 |
| Poa | compressa | 3 |
| Podospermum | laciniatum | 3 ~ |
| Polycarpon | tetraphyllum | 3 |
| Polycnemum | arvense | 3 |
| Polycnemum | verrucosum | 2 |
| Polygala | calcarea | 3 |
| Polygala | chamaebuxus | 3 ~ |
| Polygala | comosa | 3 |
| Polygonatum | odoratum | 3 |
| Potentilla | arenaria | 1 |
| Potentilla | argentea agg. | 2 |
| Potentilla | caulescens | 3 |
| Potentilla | clusiana | 3 |
| Potentilla | collina | 2 |
| Potentilla | grandiflora | 3 |
| Potentilla | heptaphylla | 3 |
| Potentilla | inclinata | 2 |
| Potentilla | intermedia | 3 |
| Potentilla | neumanniana | 3 |
| Potentilla | pusilla | 2 |
| Potentilla | recta | 3 |
| Potentilla | rhenana | 2 |
| Prunella | grandiflora | 3 |
| Prunella | laciniata | 3 |
| Prunus | fruticosa | 3 |
| Prunus | mahaleb | 3 |
| Pulsatilla | grandis | 3 |
| Pulsatilla | pratensis | 2 |
| Pulsatilla | vulgaris | 2 |
| **Q**uercus | ilex | 3 |
| Quercus | pubescens | 3 |

| GENUS | SPECIES | F number |
|---|---|---|
| Coronilla | coronata | 3 ~ |
| Coronilla | emerus | 3 |
| Coronilla | vaginalis | 3 |
| Corynephorus | canescens | 2 |
| Cotinus | coggygria | 3 |
| Cotoneaster | integerrimus | 3 |
| Cotoneaster | tomentosus | 3 |
| Crepis | praemorsa | 3 ~ |
| **D**anthonia | alpina | 3 |
| Dianthus | carthusianorum | 3 |
| Dianthus | deltoides | 3 |
| Dianthus | gratianopolitan | 2 |
| Dictamnus | albus | 3 |
| Diplotaxis | tenuifolia | 3 |
| Dorycnium | germanicum | 2 |
| Dorycnium | herbaceum | 3 |
| Draba | aizoides | 3 |
| Draba | dubia | 3 |
| Draba | tomentosa | 2 |
| **E**pipactis | atrorubens | 3 |
| Epipactis | muelleri | 3 |
| Eragrostis | megastachya | 3 |
| Eragrostis | minor | 3 |
| Eragrostis | pilosa | 3 |
| Erica | herbacea | 3 |
| Erodium | ciconium | 3 |
| Erophila | praecox | 2 |
| Erophila | spathulata | 3 |
| Erophila | verna | 3 |
| Eryngium | campestre | 3 |
| Erysimum | crepidifolium | 2 |
| Erysimum | odoratum | 2 |
| Euphorbia | chamaesyce | 3 |
| Euphorbia | cyparissias | 3 |
| Euphorbia | polychroma | 3 |
| Euphorbia | seguierana | 2 |
| Euphorbia | verrucosa | 3 |
| **F**alcaria | vulgaris | 3 |
| Festuca | alpina | 3 |
| Festuca | amethystina | 3 ~ |
| Festuca | cinerea | 2 |
| Festuca | duvalii | 1 |
| Festuca | hervieri | 3 |
| Festuca | heteropachys | 2 |
| Festuca | pallens | 2 |
| Festuca | polesica | 3 |
| Festuca | pseudovina | 3 |
| Festuca | rupicola | 3 |
| Festuca | stenantha | 3 |
| Festuca | trachyphylla | 3 |
| Festuca | valesiaca | 2 |
| Festuca | varia | 3 |
| Filago | arvensis | 3 |
| Filago | gallica | 2 |
| **R**anunculus | bulbosus | 3 |
| Rapistrum | perenne | 3 |
| Reseda | lutea | 3 |
| Rhamnus | pumilus | 3 |
| Rhamnus | saxatilis | 3 |
| Rosa | agrestis | 3 |
| Rosa | coriifolia | 3 |
| Rosa | elliptica | 3 |
| Rosa | jundzillii | 3 |
| Rosa | micrantha | 3 |
| Rosa | rubiginosa | 3 |
| Rosa | scabriuscula | 3 |
| Rosa | subcollina | 3 |
| Rosa | villosa | 3 |
| Rumex | pulcher | 3 ~ |
| Rumex | tenuifolius | 3 |
| Rumex | thyrsiflorus | 3 ~ |
| **S**alvia | pratensis | 3 |
| Sanguisorba | minor | 3 |
| Sanguisorba | muricata | 2 |
| Saponaria | ocymoides | 3 ~ |
| Saxifraga | caesia | 3 |
| Saxifraga | paniculata | 3 |
| Saxifraga | tridactylites | 2 |
| Scabiosa | canescens | 3 |
| Scabiosa | columbaria | 3 |
| Scabiosa | gramuntia | 2 |
| Scabiosa | ochroleuca | 3 |
| Scandix | pecten-veneris | 3 |
| Scleranthus | perennis | 2 |
| Scleranthus | polycarpos | 2 |
| Scleranthus | verticillatus | 2 |
| Scorzonera | austriaca | 3 ~ |
| Scorzonera | purpurea | 2 |
| Sedum | acre | 2 |
| Sedum | album | 2 |
| Sedum | annuum | 3 |
| Sedum | dasyphyllum | 3 |
| Sedum | forsteranum | 3 |
| Sedum | maximum | 3 |
| Sedum | rubens | 3 |
| Sedum | rupestre agg. | 2 |
| Sedum | sexangulare | 2 |
| Sedum | spurium | 3 |
| Sedum | vulgare | 3 |
| Sempervivum | arachnoideum | 2 |
| Sempervivum | montanum | 3 |
| Sempervivum | tectorum | 2 |
| Senecio | erucifolius | 3 ~ |
| Senecio | inaequidens | 3 |
| Senecio | viscosus | 3 |
| Seseli | annuum | 3 |
| Seseli | hippomarathrum | 2 |
| Seseli | libanotis | 3 |

| GENUS | SPECIES | F number |
|---|---|---|
| Filago | lutescens | 3 |
| Filago | minima | 2 |
| Filago | pyramidata | 2 |
| Filago | vulgaris | 3 |
| Filipendula | vulgaris | 3 ~ |
| Fragaria | viridis | 3 |
| Fraxinus | ornus | 3 |
| Fumana | procumbens | 2 |
| **G**agea | bohemica | 2 |
| Galeopsis | angustifolia | 2 |
| Galium | glaucum | 2 |
| Galium | lucidum | 3 |
| Galium | parisiense | 3 |
| Galium | tricornutum | 3 |
| Gentiana | cruciata | 3 |
| Gentianella | ciliata | 3 |
| Geranium | sanguineum | 3 |
| Globularia | punctata | 2 |
| Gypsophila | fastigiata | 2 |
| **H**elianthemum | apenninum | 2 |
| Helianthemum | canum | 2 |
| Helianthemum | nummularium | 3 |
| Helianthemum | ovatum | 3 |
| Helichrysum | arenarium | 2 |
| Herniaria | glabra | 3 |
| Herniaria | hirsuta | 3 |
| Hieracium | ambiguum | 3 |
| Hieracium | amplexicaule | 3 |
| Hieracium | auriculoides | 3 |
| Hieracium | bauhinii | 3 |
| Hieracium | bifurcum | 2 |
| Hieracium | calodon | 3 |
| Hieracium | cymosum | 3 |
| Hieracium | echioides | 2 |
| Hieracium | fallax | 2 |
| Hieracium | franconicum | 2 |
| Hieracium | peleterianum | 3 |
| Hieracium | rothianum | 2 |
| Hieracium | wiesbaurianum | 3 |
| Hierochloe | australis | 3 ~ |
| Himantoglossum | hircinum | 3 |
| Hippocrepis | comosa | 3 |
| Hirschfeldia | incana | 3 |
| Holosteum | umbellatum | 3 |
| Hornungia | petraea | 2 |
| Hypericum | elegans | 3 ~ |
| Hypochoeris | glabra | 3 |
| Hyssopus | officinalis | 2 |
| **I**nula | germanica | 3 |
| Inula | hirta | 3 |
| Inula | spiraeifolia | 3 |
| Iris | aphylla | 3 |
| Iris | germanica | 3 |
| Iris | sambucina | 3 |
| Silene | chlorantha | 2 |
| Silene | conica | 2 |
| Silene | noctiflora | 3 ~ |
| Silene | nutans | 3 |
| Silene | otites | 2 |
| Silene | rupestris | 3 |
| Sisymbrium | irio | 3 |
| Sisymbrium | volgense | 3 |
| Solanum | sarrachoides | 3 |
| Sorbus | danubialis | 3 |
| Sorbus | mougeotii | 3 |
| Spergula | morisonii | 3 |
| Spergula | pentandra | 2 |
| Stachys | annua | 3 |
| Stachys | germanica | 3 |
| Stachys | recta | 3 |
| Stipa | bavarica | 1 |
| Stipa | capillata | 2 |
| Stipa | eriocaulis | 2 |
| Stipa | eriocaulis ssp. | 2 |
| Stipa | joannis | 2 |
| Stipa | tirsa | 3 |
| Stipa | pulcherrima | 1 |
| **T**araxacum | laevigatum agg. | 3 |
| Taraxacum | obliquum agg. | 3 |
| Teesdalia | nudicaulis | 3 |
| Teucrium | botrys | 2 |
| Teucrium | chamaedrys | 2 |
| Teucrium | montanum | 1 |
| Thalictrum | minus | 3 |
| Thesium | bavarum | 3 ~ |
| Thesium | linophyllon | 2 |
| Thesium | rostratum | 3 ~ |
| Thymus | praecox | 3 |
| Thymus | pulegioides ssp | 2 |
| Thymus | serpyllum | 2 |
| Trifolium | alpestre | 3 ~ |
| Trifolium | arvense | 3 |
| Trifolium | montanum | 3 ~ |
| Trifolium | ornithopoides | 3 |
| Trifolium | retusum | 3 |
| Trifolium | rubens | 3 |
| Trifolium | scabrum | 2 |
| Trifolium | striatum | 3 |
| Tordylium | maximum | 3 |
| Trinia | glauca | 1 |
| Tuberaria | guttata | 2 |
| Turgenia | latifolia | 3 |
| **V**accaria | hispanica | 2 |
| Ventenata | dubia | 3 |
| Verbascum | blattaria | 3 |
| Verbascum | lychnitis | 3 |
| Verbascum | phoeniceum | 3 |
| Verbascum | pulverulentum | 3 |

| GENUS | SPECIES | F number | |
|---|---|---|---|
| Iris | variegata | 3 | |
| Isatis | tinctoria | 3 | |
| **J**asione | montana | 3 | |
| Jovibarba | sobolifera | 2 | |
| Juniperus | sabina | 3 | |
| Jurinea | cyanoides | 2 | |
| **K**ernera | saxatilis | 3 | |
| Kochia | laniflora | 2 | |
| Koeleria | glauca | 3 | |
| Koeleria | macrantha | 3 | |
| Koeleria | vallesiana | 1 | |
| **L**aburnum | anagyroides | 3 | |
| Lactuca | perennis | 2 | |
| Lactuca | viminea | 3 | |
| Lappula | squarrosa | 3 | |
| Lathyrus | aphaca | 3 | |
| Lathyrus | niger | 3 | |
| Lathyrus | pannonicus | 3 | ~ |
| Leontodon | incanus | 3 | |
| Lepidium | graminifolium | 3 | |

| GENUS | SPECIES | F number |
|---|---|---|
| Veronica | austriaca | 3 |
| Veronica | dillenii | 2 |
| Veronica | praecox | 2 |
| Veronica | prostrata | 2 |
| Veronica | spicata | 3 |
| Veronica | teucrium | 3 |
| Veronica | verna | 2 |
| Veronica | verna agg. | 2 |
| Veronica | vindobonensis | 3 |
| Vicia | lathyroides | 2 |
| Vicia | tenuifolia | 3 |
| Vincetoxicum | hirundinaria | 3 |
| Viola | collina | 3 |
| Viola | hirta | 3 |
| Viola | rupestris | 3 |
| Viola | tricolor ssp. | 3 |
| Vulpia | bromoides | 3 |
| Vulpia | myurus | 2 |
| **W**oodsia | ilvensis | 3 |

**Table A3-4. 2: Legend F number acc. to Ellenberg**

| Value | Description | Explanation |
|---|---|---|
| **1** | Severe drought indicator | Plant ever on dry soils, viable on drying up soils |
| **2** | | |
| **3** | Drought indicator | Plant mainly on dry soils, partly on moderate dry soils, missing on moist soils |
| ~ | | Periodically dry and wet |

**Table A3-5: Hazard indicator 8, Flooding and extreme waterlogging**

| Score | Characteristic | Orientation, check species of F >= 9 in list below |
|---|---|---|
| **2** | No or low risk of flooding, low or moderate level of waterlogging | All plants of F numbers < 9 (not in list below), a few sub-dominant species may have 9 or 10, species having F =>11 missing |
| **1.5** | Low risk of flooding, longer ponding and wetness | Some species of F=9 or higher, some flooding indicators (=), species having F =>11 missing |
| **1** | Medium risk of flooding, very long period of wetness | Many plants of F = 9 or higher, some plants of F less than 9, species having F =12 largely missing, some flooding indicators (=) |
| **0.5** | High probability of flooding, very long period of wetness | Many plants of F = >9, many flooding indicators, some species of F less than 9 |
| **0** | Extreme high probability of flooding, extreme waterlogging | Most plants of F > 9 or many flooding indicators, some sub-dominant species may have 9 or less, drought indicators F<=3 missing |

**Table A3-5.1: Plant list of F numbers => 9**

| GENUS | SPECIES | F number | | GENUS | SPECIES | F number | |
|---|---|---|---|---|---|---|---|
| Acorus | calamus | 10 | | Ludwigia | palustris | 9 | = |
| Agrostis | canina | 9 | | Luronium | natans | 11 | |
| Alchemilla | coriacea | 9 | | Lycopodiella | inundata | 9 | = |
| Alchemilla | effusa | 9 | | Lycopus | europaeus | 9 | = |
| Alchemilla | straminea | 9 | | Lycopus | exaltatus | 9 | = |
| Aldrovanda | vesiculosa | 12 | | Lysimachia | thyrsiflora | 9 | = |
| Alisma | gramineum | 11 | | Marsilea | quadrifolia | 10 | |
| Alisma | lanceolatum | 10 | | Mentha | aquatica | 9 | = |
| Alisma | plantago-aquatica | 10 | | Menyanthes | trifoliata | 9 | = |
| Alnus | glutinosa | 9 | = | Mimulus | guttatus | 9 | = |
| Alopecurus | aequalis | 9 | = | Minuartia | stricta | 9 | |
| Anagallis | tenella | 9 | | Montia | fontana | 9 | |
| Andromeda | polifolia | 9 | | Myosotis | laxa | 9 | = |
| Angelica | archangelica | 9 | = | Myosotis | rehsteineri | 10 | |
| Apium | inundatum | 10 | | Myrica | gale | 9 | |
| Apium | nodiflorum | 10 | | Myriophyllum | alternifolium | 12 | |
| Arabis | soyeri | 9 | = | Myriophyllum | spicatum | 12 | |
| Armeria | purpurea | 10 | | Myriophyllum | verticillatum | 12 | |
| Azolla | caroliniana | 11 | | Najas | flexilis | 12 | |
| Azolla | filiculoides | 11 | | Najas | intermedia | 12 | |
| Baldellia | ranunculoides | 10 | | Najas | marina | 12 | |
| Berula | erecta | 10 | | Najas | minor | 12 | |
| Betula | humilis | 9 | | Narthecium | ossifragum | 9 | |
| Betula | nana | 9 | | Nasturtium | officinale agg. | 10 | |

| GENUS | SPECIES | F number |
|---|---|---|
| Bidens | cernua | 9 = |
| Bidens | connata | 9 = |
| Bidens | radiata | 9 = |
| Bidens | tripartita | 9 = |
| Bolboschoenus | maritimus | 10 |
| Butomus | umbellatus | 10 |
| Butomus | umbellatus var. | 11 |
| Calamagrostis | canescens | 9 = |
| Calamagrostis | stricta | 9 ~ |
| Caldesia | parnassifolia | 10 |
| Calla | palustris | 9 = |
| Callitriche | brutia | 10 |
| Callitriche | cophocarpa | 10 |
| Callitriche | hamulata | 10 |
| Callitriche | hermaphroditica | 12 |
| Callitriche | obtusangula | 11 |
| Callitriche | palustris | 11 |
| Callitriche | platycarpa | 11 |
| Callitriche | stagnalis | 10 |
| Caltha | palustris | 9 = |
| Calycocorsus | stipitatus | 9 |
| Cardamine | amara | 9 = |
| Cardamine | matthioli | 9 ~ |
| Cardamine | palustris | 9 |
| Cardamine | rivularis | 9 ~ |
| Carex | acutiformis | 9 ~ |
| Carex | appropinquata | 9 = |
| Carex | aquatilis | 9 = |
| Carex | atherodes | 9 = |
| Carex | brunnescens | 9 ~ |
| Carex | canescens | 9 |
| Carex | cespitosa | 9 = |
| Carex | chordorrhiza | 9 = |
| Carex | davalliana | 9 |
| Carex | diandra | 9 = |
| Carex | dioica | 9 |
| Carex | disticha | 9 = |
| Carex | elata | 10 |
| Carex | elongata | 9 ~ |
| Carex | flava | 9 |
| Carex | gracilis | 9 = |
| Carex | heleonastes | 9 = |
| Carex | hostiana | 9 |
| Carex | juncifolia | 9 = |
| Carex | laevigata | 9 = |
| Carex | lasiocarpa | 9 = |
| Carex | lepidocarpa | 9 |
| Carex | limosa | 9 = |
| Carex | microglochin | 9 |
| Carex | norvegica | 9 ~ |
| Carex | oederi | 9 |
| Carex | paniculata | 9 |
| Carex | pauciflora | 9 |
| Nuphar | lutea | 11 |
| Nuphar | pumila | 11 |
| Nymphaea | alba | 11 |
| Nymphaea | candida | 11 |
| Nymphoides | peltata | 11 |
| Oenanthe | aquatica | 10 |
| Oenanthe | conioides | 10 |
| Oenanthe | fistulosa | 9 = |
| Oenanthe | fluviatilis | 11 |
| Oenanthe | peucedanifolia | 9 ~ |
| Orchis | palustris | 9 ~ |
| Pedicularis | palustris | 9 = |
| Peucedanum | palustre | 9 = |
| Phalaris | arundinacea | 9 = |
| Phragmites | australis | 10 |
| Pilularia | globulifera | 9 = |
| Pinguicula | leptoceras | 9 |
| Poa | palustris | 9 = |
| Polygala | amarella | 9 |
| Polygonum | amphibium | 11 |
| Potamogeton | acutifolius | 11 |
| Potamogeton | alpinus | 12 |
| Potamogeton | angustifolius | 12 |
| Potamogeton | berchtoldii | 12 |
| Potamogeton | coloratus | 11 |
| Potamogeton | compressus | 12 |
| Potamogeton | crispus | 12 |
| Potamogeton | filiformis | 12 |
| Potamogeton | friesii | 11 |
| Potamogeton | gramineus | 12 |
| Potamogeton | helveticus | 12 |
| Potamogeton | lucens | 12 |
| Potamogeton | natans | 11 |
| Potamogeton | nitens | 12 |
| Potamogeton | nodosus | 12 |
| Potamogeton | obtusifolius | 12 |
| Potamogeton | pectinatus | 12 |
| Potamogeton | pectinatus agg. | 12 |
| Potamogeton | perfoliatus | 12 |
| Potamogeton | polygonifolius | 10 |
| Potamogeton | praelongus | 12 |
| Potamogeton | pusillus | 12 |
| Potamogeton | pusillus agg. | 12 |
| Potamogeton | rutilus | 12 |
| Potamogeton | trichoides | 11 |
| Potentilla | palustris | 9 = |
| Ranunculus | aquatilis | 11 |
| Ranunculus | baudotii | 10 |
| Ranunculus | circinatus | 12 |
| Ranunculus | flammula | 9 ~ |
| Ranunculus | fluitans | 12 |
| Ranunculus | hederaceus | 9 = |
| Ranunculus | lingua | 10 |

| GENUS | SPECIES | F number |
|---|---|---|
| Carex | paupercula | 9 |
| Carex | pseudocyperus | 9 = |
| Carex | pulicaris | 9 |
| Carex | riparia | 9 = |
| Carex | rostrata | 10 |
| Carex | trinervis | 9 |
| Carex | tumidicarpa | 9 |
| Carex | vaginata | 9 |
| Carex | vesicaria | 9 = |
| Catabrosa | aquatica | 9 = |
| Ceratophyllum | demersum | 12 |
| Ceratophyllum | submersum | 12 |
| Chrysosplenium | oppositifolium | 9 = |
| Cicuta | virosa | 9 = |
| Cladium | mariscus | 10 |
| Cochlearia | pyrenaica | 9 = |
| Cucubalus | baccifer | 9 = |
| Cyperus | longus | 9 = |
| **D**actylorhiza | majalis ssp. | 9 |
| Dactylorhiza | praetermissa | 9 |
| Dactylorhiza | traunsteineri | 9 = |
| Deschampsia | litoralis | 10 |
| Deschampsia | setacea | 9 = |
| Deschampsia | wibeliana | 9 = |
| Drosera | anglica | 9 = |
| Drosera | intermedia | 9 = |
| Drosera | obovata | 9 |
| Drosera | rotundifolia | 9 |
| Dryopteris | cristata | 9 |
| **E**chinocystisus | lobata | 9 = |
| Elatine | alsinastrum | 9 = |
| Elatine | hexandra | 9 = |
| Elatine | triandra | 9 = |
| Eleocharis | acicularis | 10 |
| Eleocharis | mamillata | 10 |
| Eleocharis | multicaulis | 10 |
| Eleocharis | palustris | 10 |
| Eleocharis | parvula | 10 |
| Eleocharis | quinqueflora | 9 |
| Eleocharis | uniglumis | 9 = |
| Elodea | canadensis | 12 |
| Elodea | nuttallii | 12 |
| Epilobium | alsinifolium | 9 |
| Epilobium | nutans | 9 |
| Epilobium | palustre | 9 |
| Epilobium | parviflorum | 9 = |
| Epilobium | roseum | 9 = |
| Epipactis | palustris | 9 ~ |
| Equisetum | fluviatile | 10 |
| Equisetum | variegatum | 9 |
| Eriophorum | angustifolium | 9 = |
| Eriophorum | gracile | 9 = |
| Eriophorum | latifolium | 9 |

| GENUS | SPECIES | F number |
|---|---|---|
| Ranunculus | ololeucos | 10 |
| Ranunculus | peltatus | 12 |
| Ranunculus | penicillatus | 11 |
| Ranunculus | reptans | 10 |
| Ranunculus | sceleratus | 9 = |
| Ranunculus | trichophyllus | 12 |
| Ranunculus | tripartitus | 10 |
| Rhynchospora | alba | 9 = |
| Rhynchospora | fusca | 9 = |
| Ribes | nigrum | 9 = |
| Rorippa | amphibia | 10 |
| Rorippa | anceps | 9 = |
| Rumex | hydrolapathum | 10 |
| Rumex | maritimus | 9 = |
| Rumex | palustris | 9 = |
| Ruppia | cirrhosa | 12 |
| Ruppia | maritima | 10 |
| **S**agittaria | sagittifolia | 10 |
| Salicornia | dolichostachya | 9 = |
| Salix | cinerea | 9 ~ |
| Salix | myrtilloides | 9 |
| Salvinia | natans | 11 |
| Saxifraga | aizoides | 9 = |
| Saxifraga | hirculus | 9 = |
| Saxifraga | oppositifolia s | 9 = |
| Saxifraga | stellaris | 9 = |
| Scheuchzeria | palustris | 9 = |
| Schoenoplectus | americanus | 10 |
| Schoenoplectus | carinatus | 11 |
| Schoenoplectus | lacustris | 11 |
| Schoenoplectus | mucronatus | 10 |
| Schoenoplectus | tabernaemontani | 10 |
| Schoenoplectus | triqueter | 10 |
| Schoenus | nigricans | 9 = |
| Scirpus | radicans | 9 = |
| Scolochloa | festucacea | 10 |
| Scrophularia | auriculata | 9 = |
| Scrophularia | umbrosa | 9 = |
| Scutellaria | galericulata | 9 = |
| Scutellaria | minor | 9 |
| Sedum | villosum | 9 |
| Senecio | congestus | 9 = |
| Senecio | fluviatilis | 9 = |
| Senecio | paludosus | 9 = |
| Silene | pusilla | 9 = |
| Sium | latifolium | 10 |
| Sparganium | angustifolium | 11 |
| Sparganium | emersum | 10 |
| Sparganium | erectum | 10 |
| Sparganium | minimum | 11 |
| Spartina | townsendii agg. | 9 = |
| Spiranthes | aestivalis | 9 |
| Spirodela | polyrhiza | 11 |

| GENUS | SPECIES | F number | |
|---|---|---|---|
| Eriophorum | scheuchzeri | 9 | = |
| Eriophorum | vaginatum | 9 | ~ |
| **G**alium | elongatum | 9 | |
| Galium | palustre | 9 | = |
| Galium | palustre agg. | 9 | |
| Gentiana | utriculosa | 9 | ~ |
| Glyceria | fluitans | 9 | = |
| Glyceria | nemoralis | 9 | = |
| Glyceria | maxima | 10 | |
| Glyceria | plicata | 10 | |
| Groenlandia | densa | 12 | |
| **H**ammarbya | paludosa | 9 | = |
| Hierochloe | odorata agg. | 9 | |
| Hippuris | vulgaris | 10 | |
| Hottonia | palustris | 12 | |
| Hydrilla | verticillata | 12 | |
| Hydrocharis | morsus-ranae | 11 | |
| Hydrocotyle | vulgaris | 9 | ~ |
| Hypericum | elodes | 9 | = |
| **I**ris | pseudacorus | 9 | = |
| Isolepis | fluitans | 10 | |
| Isolepis | setacea | 9 | |
| Isotes | echinospora | 12 | |
| Isotes | lacustris | 12 | |
| **J**uncus | alpino-articula | 9 | |
| Juncus | articulatus | 9 | |
| Juncus | atratus | 9 | ~ |
| Juncus | bulbosus | 10 | |
| Juncus | filiformis | 9 | |
| Juncus | stygius | 9 | = |
| Juncus | triglumis | 9 | |
| **K**obresia | simpliciuscula | 9 | |
| **L**edum | palustre | 9 | |
| Leersia | oryzoides | 10 | |
| Lemna | gibba | 11 | |
| Lemna | minor | 11 | |
| Lemna | trisulca | 12 | |
| Leucojum | aestivum | 9 | = |
| Liparis | loeselii | 9 | = |
| Littorella | uniflora | 10 | |
| Lobelia | dortmanna | 10 | |

| GENUS | SPECIES | F number | |
|---|---|---|---|
| Stellaria | crassifolia | 9 | |
| Stellaria | palustris | 9 | ~ |
| Stratiotes | aloides | 11 | |
| Subularia | aquatica | 10 | |
| Swertia | perennis | 9 | |
| **T**araxacum | fontanum agg. | 9 | |
| Trapa | natans | 11 | |
| Trichophorum | alpinum | 10 | |
| Trichophorum | cespitosum | 9 | |
| Trichophorum | cespitosum agg. | 9 | |
| Trichophorum | germanicum | 9 | |
| Triglochin | palustre | 9 | = |
| Typha | angustifolia | 10 | |
| Typha | latifolia | 10 | |
| Typha | minima agg. | 9 | = |
| Typha | shuttleworthii | 10 | |
| **U**rtica | kioviensis | 10 | |
| Utricularia | australis | 12 | |
| Utricularia | bremii | 12 | |
| Utricularia | intermedia | 12 | |
| Utricularia | intermedia agg. | 12 | |
| Utricularia | minor agg. | 10 | |
| Utricularia | ochroleuca | 12 | |
| Utricularia | vulgaris | 12 | |
| Utricularia | vulgaris agg. | 12 | |
| **V**accinium | microcarpum | 9 | |
| Vaccinium | oxycoccos | 9 | |
| Vaccinium | oxycoccus agg. | 9 | |
| Vallisneria | spiralis | 12 | |
| Veronica | anagallis-aquatica | 9 | = |
| Veronica | anagalloides | 9 | = |
| Veronica | beccabunga | 10 | |
| Veronica | catenata | 9 | = |
| Veronica | scutellata | 9 | = |
| Viola | epipsila | 9 | = |
| Viola | palustris | 9 | |
| **W**ahlenbergia | hederacea | 9 | |
| Wolffia | arrhiza | 11 | |
| **Z**annichellia | palustris | 12 | |
| Zostera | marina | 12 | |
| Zostera | noltii | 12 | |

**Table A3-5.2: Legend F number acc. to Ellenberg**

| Value | Description | Explanation |
|---|---|---|
| 9 | Wetness indicator | Mainly on very wet soils |
| 10 | | Water plant, viable without inundation for a longer period |
| 11 | Water plant | Roots in water, periodically above water |
| 12 | Submerged plant | Mainly below water |
| = | | Flooding, inundation |
| ~ | | Periodically dry and wet |

To maintain soil quality for feeding coming generations with healthy agricultural products and ensuring prospering agricultural regions, soils should be used wisely.
This requires knowledge of their health in terms of comparable indicators of soil quality.
In this paper an empirical approach of Soil Quality Rating is presented. It is based on the interpretation of a soil profile by simple scoring tables.
Soil deficiencies for cropping or grazing become apparent.

Finally, an empirical rating score ranging from 100 (prime farmland) to 0 (no farming possible) will allow to compare the quality of the soil in front of our eye with other soils on our planet.

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