

Visual Soil – Field Assessment Tool – The Methodology

**A Methodology of a
Visual Soil - Field Assessment Tool
- to support, enhance and contribute
to the LADA program**

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Introduction and background

The development of a farmer usable methodology for a Visual Soil – Field Assessment Tool (VS-Fast) would appear to fit well with the aims, requirements and current actions of many International projects dealing with long-term sustainability of land use within a framework that includes themes of capacity building. The methodology is designed for farmers' (and their advisors') use with the prime aim of providing “a cheap, repeatable, usable-by-farmers, immediate means of land degradation assessment” in poor/developing countries. McGarry and Sharp (2001) outlined the basis and practicalities of a VS-Fast methodology and how this may be taught to farmers.

Matson et al (1997) presented a methodological approach to assessing and monitoring the principal **constraints** to agricultural production. They recognised the rapid intensification of agriculture and associated food production over the past 50 years. The challenge, as they see it, is to achieve ecologically based management strategies to ensure sustainability in the intensification of agricultural production, particularly mitigating land degradation and off-site effects. The Matson et al (1997) approach has two main steps, that fit directly with the concepts, practices and necessity for a VS-Fast methodology:

1. identify the constraints to agricultural production; particularly water and nutrients
2. develop simple yet robust “key” indicators of these constraints, towards:
 - a. building capacity and support networks to ensure the constraints are met (overcome)
 - b. monitor change with, and support good practices

Desertification, and more generally land degradation in drylands through changed and intensive land use, is recognised as a prime environmental problem on a global scale (as reviewed by Su et al 2004). Logical then, is that the first user of this current version of VS-Fast is the Land Degradation Assessment in Drylands project of FAO (LADA). The prime aim of LADA is to assess and combat land degradation in drylands particularly *via* the development and building of “Land Monitoring Tools”. VS-Fast is one such tool.

Land assessment and monitoring, in the terms of developing a farmer-level methodology of VS-Fast, has three principal objectives:

- to assess the nature and causes, and quantify the extent and severity of land degradation, and its impact/consequences on the environment and human society,
- to build the capacity to achieve the above, towards
- building capabilities to design and plan interventions to improve land management towards mitigating land degradation, from the individual farm scale, upwards.

The VS-Fast methodology describes and evaluates the morphological condition of soils in the field. This is a more rapid and immediate method of soil assessment than the conventional sets of soil physical measurements commonly used, eg bulk density, disc permeameters, soil strength (penetrometers), etc. Emphasis with VS-Fast is the

assessment, both tactile/qualified and quantified, of soil physical condition (soil structure units and porosity) as well as soil colour, root development, soil fauna, slaking and dispersion, organic matter status and water infiltration.

The measurements included in the VS-Fast methodology were not selected at random. Rather, these measures (of dispersion, pH, water infiltration, organic carbon and biota) are seen as a **critical set** in presenting, investigating and rationalising important elements of land degradation, globally. Also important are the synergies between the individual measures, and the known links between the measurements and specific types of land degradation. Lal (1997) discusses the importance of measuring soil organic levels and links depleted levels with soil dispersion (indicative of weak structure), leading to accelerated soil erosion. Similarly, as reviewed by Su et al (2004), the conversion of grassland to cropping land in desertification prone areas has caused decline in soil structure and rapid loss of soil organic matter. They also linked these types of degradation with reduction in soil nutrients (N and total P) associated with the removal of fine fractions. Matson et al (1997) state that the link between the loss of soil organic matter with the introduction of permanent agriculture “has been intensively studied and well documented”. Organic matter is both vital for nutrient release and critical in maintaining both soil structure and water holding capacity and infiltration; hence reducing erosion potential. Saturated hydraulic conductivity (water infiltration) is recognised as “one of the most important soil properties” that controls a wide range of inter-related soil properties that directly impact on land and environmental quality, including water infiltration, soil profile re-fill, surface runoff, leaching of pesticides and migration of pollutants from contaminated sites to groundwater (Bagarello and Sgroi 2004).

An essential element of VS-Fast in terms of land assessment and capacity building of locals is that the product needs to be both **simply presented** but also scientifically **robust**. Simplicity of presentation is essential to ensure that the most important techniques of soil assessment are presented, readily understood and usable at the farm level. The need to readily translate the system into various, world languages (even sign language) is an important consideration. Additionally, all techniques must be robust. Though presented simply, all must be firmly based on both strong science and a long lineage of usage. The marrying of farmer usability and the important and inevitable peer-reviewing of the techniques’ use and interpretation will both withstand external review/criticism and provide a base for transfer of information between farms, regions and countries.

As such, the VS-Fast system aims to fill the need for a simple, repeatable, low cost monitoring system to capture the condition and trend, and extent and ramifications of soil degradation, and organic matter and soil biota decline (both natural/inherent and anthropogenic) in cropping, grazing and wood lands, worldwide.

Development of a Visual Soil – Field Assessment Tool methodology

The development of this VS-Fast methodology will satisfy several, current requirements:

1. a continuing need for a simple, low cost monitoring system for capturing the condition and trend, and extent and ramifications of soil degradation and

- organic matter decline (both natural/inherent and anthropogenic) in the cropping, grazing and wood lands of the World
2. the provision of a simple, rapid method to ensure that either small areas are investigated in detail or large areas are evaluated quickly
 3. the development and testing of an effective assessment methodology, with immediate application for land degradation in drylands
 4. a (very) low cost, field method using the farmer (and local agronomist) perspectives and knowledge towards capacity building and empowering of local people; in this way provide ownership and subsequent use of the collected information to increase their understanding of the impact of “their management on their soil”
 5. a most illustrative (many photographs) methodology with simple, repeatable measures using (where possible) everyday apparatus and low cost chemicals, eg spade, tin can, water, saucer, etc.

The aim with a low cost and simple methodology, such as VS-Fast, recognises the need for:

- a. an immediate, farmer-friendly and usable techniques that can be taught at “train the trainer” and “farmer training schools” – to teach, support and empower farmers who daily come face-to-face with soil problems, and who are best able to rationalise the cause and implement solutions, commonly without laboratory or research facilities,
- b. rapid analysis of areas of special risk (“hot spots”) and areas where degradation is controlled (“bright spots”) undertaken and linked to policy at national level, and
- c. field investigations within selected countries towards resourcing and implementing:
 - (i) team(s) of personnel with necessary skills to conduct local level assessment,
 - (ii) interaction with land users/stakeholders – training, empowering and co-seeking solutions and rehabilitation strategies, and
 - (iii) a library of images and worked examples – sourced from “hot” and “bright” spots.

Currently available systems of Soil Visual Assessment

Visual Soil - Field Assessment is firmly founded on decades of pedological (field soil description) methods and practices, where most world nations have a system of describing and semi-quantifying soil condition. A recent review by Dr Tom Batey of Aberdeen University, Scotland (personal communication) lists 11 such systems; three emanating from Scotland, two from Australia, and one from each of New Zealand, Switzerland, France and the Netherlands (Appendix A, below).

The VS-Fast system as presented here draws heavily on selected components of two of these systems (Shepherd 2000; McKenzie 1998) as well as from a newly developing system (Moody in press). Soil structure diagrams, specifically, are taken from an excellent, illustrative WWW site (NASA 2004) which provides a step by step guide through several Soil Characterization Protocols. A most comprehensive set of (mainly) field tests for assessing soil quality is provided by the USDA (1999). Additionally, a new initiative presents short film clips (on CD), demonstrating tests such as pH, dispersion and slaking, and soil auguring (Pillai-McGarry 2004)

When to use the VS-Fast system

There are two fundamental circumstances under which soil condition can be assessed (USDA 1999). Both recognise that VS-Fast is based on **comparative** assessments where assessments are either:

1. comparisons of one situation to a reference soil condition, or
2. the monitoring of change in soil condition with time and/or as a result of altered practices.

In this light, there are several exemplars of possible testing situations:

1. a comparison of agricultural ground with relatively “untouched” adjoining tree or fence lines, permits impact statements, evaluating current land practices,
2. before development of a new area of land to diagnose inherent problems that require short or long-term amelioration practices (McKenzie 1998),
3. after preliminary cultivation or sowing of new land, to assess the effect and if the practice achieved the desired outcome (McKenzie 1998),
4. after some seasons (or years) of cropping / grazing of a field to assess soil condition with long-term practices, to determine if current practices are improving or degrading soil condition, and to aid decisions on changing current practices to achieve amelioration of problems, and
5. continuing the evaluations with time to facilitate trend analysis, particularly as farm practices change as a result of earlier assessments of soil condition.

More specifically, there are times within cropping or grazing seasons where soil inspection is required to check possible degradation or improvements in soil condition (from recent practices) (from McKenzie 1998), for example:

1. immediately after harvests, especially when machinery has trafficked wet soil,
2. immediately after a rotation (or break or cover) crop to assess improvements in soil condition (root penetration, earthworm counts, etc) and
3. after a test run or the purchase and use of new equipment, for example tillage or sowing equipment, tractors or tyre - types etc.

Methods of the Visual Soil – Field Assessment Tool

The VS-Fast system is still in the development phase. However, the general aim is to compile a “Field Test Kit” for use by farmers “on-farm”. The system has two levels of methods and tests. The first set is the “core” tests of the system and provides six descriptors of soil condition. Depending on time, budget, availability of apparatus and operator skills, all or selected measures from the second set of tests should also be conducted. Essential will be the establishment, in time, of a firm link between the VS-Fast scores from the first set of methods and the quantified data from the second set.

The scoring system

- At present this is based on the scoring procedure of Shepherd (2000), recognising both its simplicity and also its demonstrated link to more quantifiable indicators of soil and land quality.

Appendix B (below) provides the scoring sheet – for each of:

- A:** the descriptors of site location, pre-history and current soil surface condition, and the condition of the top 30 to 40 cm of soil, and
- B:** the field measures of soil condition (the more conducted the better; time and resources considered).

Appendix C (below) provides six International exemplars of the application of the VS-Fast methodology (for the soil visual descriptors).

The scoring system

The scoring system is currently under discussion. However, scores are attributed to each of the variables noted in the soil such as presence of tillage pan, root penetration/development, earthworm counts, etc and multiplied by fixed weighted values. The weighting reflects the importance of the indicator / measurement.

Overview of the VS-Fast system

A. Site selection & description

1. Choosing a site to investigate *
1. Choosing where to dig the hole(s) *
2. Site history *
3. “Walk-in” information *
 - a. Residue and/or stubble cover *
4. Site photo or sketch *

B. Digging the hole

1. Spade technique
2. Hole size and depth

C. Soil visual descriptors

1. Soil depths *
2. Soil structure *
 - a. type, size, grade and consistency *
 - b. tillage pan **
 - c. aggregate size distribution **
3. Soil texture *
4. Soil colour *
5. Earthworms **
6. Roots **
7. Photo or sketch *

D. Soil measurements

1. Slaking and dispersion **
2. Soil pH *
3. Water infiltration **
4. Soil organic carbon – labile fraction **

* Each of these attributes is RECORDED but not scored

** Each of these attributes is RECORDED **AND** scored

A. Site selection & description

1. Choosing a site to investigate
2. Choosing where to dig the hole(s)
3. Site history
4. “Walk-in” information
 - a. Residue and/or stubble cover
5. Site photo or sketch

A 1. Choosing a site to investigate

There can be many reasons for site selection. Comparisons are commonly:

- side by side comparisons of different management systems, for example no-till with conventional, or either side of a fence line with different management on either side
- problematic soils, for example where there are visible signs of poor drainage, shallow root systems, surface puddling or crusting, etc
- “before and after” scenarios, for example before and after the pass of a harvester, or tillage equipment, or after cattle/sheep grazing
- wheel tracks and non wheel tracks
- untouched (natural) areas with agricultural areas
- around gates or water trough areas (severe impact areas) compared to the “rest of field”

RECORD the rationale for site selection as this is an important means of interpreting the subsequent observations and measurements.

A 2. Choosing where to dig the hole(s)

It is important to dig holes in representative areas, depending on the reason for the investigation. One-on-one discussions with the farmer, farm advisor or a local expert are vital to this, to choose locations that they believe are problematic, or typical of some practice, or where they have been attempting some new/alterd practice, or where rotation/cover crops have been grown, or where they think there is some problem, etc.

RECORD the rationale for selecting the locations(s) for hole digging as this is an important means of interpreting the subsequent observations and measurements.

A 3. Site history

Again, discussions with farmer/advisor/local expert are most important.

RECORD all possible information as this is the basis of interpreting subsequent observations and measurements.

Items of management history to record include:

- past and present:
 1. tillage: type, direction and depths
 2. pulled by: hand, animal, tractor (size)
 3. minimum or no till (and for how many years/seasons)

4. crops: type, growth, yield (above or below expectations)
5. fertilization (and response to)
6. land levelling (and if in specific areas of a field)
7. rainfall (recent and historical), for example “very wet at last harvest”
8. soil ameliorants applied, for example lime, gypsum
9. any attempts at introducing “best” or altered practices

A 4. “Walk-in” information

These are an important set of visible, surface “clues”, commonly observed and recorded as one walks into a new site, walking towards the location chosen for the soil hole excavation. There can be both (i) negative and (ii) positive indicators.

(i) Observe and **RECORD** the incidence of such **surface** soil and crop conditions, generally considered as **negative** indicators of soil and crop growing conditions:

- clods / rough soil surface (Fig. 1)
- soil dispersion (white sand grains) on soil surface
- water ponding on surface or in wheel tracks
- hard setting surface or crust
- poor seedling emergence due to crusting or presence of large surface aggregates
- poor crop growth in patches or strips
- shallow or stunted roots “right angle root disease” (evident as last year’s crop residue, lying on the soil surface)
- poor crop growth
 - any visible patterns
 - if late in season or early
 - if crop a specific colour
- uneven crop ripening
- cracks etc

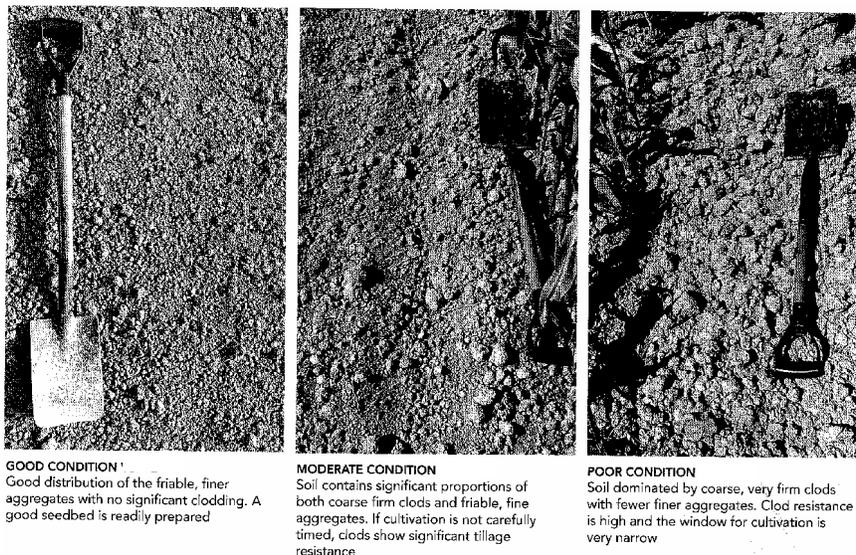


Fig. 1 Surface soil cloddiness. Finely aggregated soil on the left, through to coarsely structured soil (right) with strong implications for seed placement, germination and water infiltration (from Shepherd 2000).

(ii) Observe and **RECORD** the incidence of such **surface** soil and crop conditions, generally considered as **positive** indicators of soil and crop growing conditions:

(a) evidence of improved surface soil condition, such as:

- finely aggregated seedbeds (Fig. 1)
- earthworm castes or burrows
- permanent wheel or feet tracks

(b) the incidence and percentage of soil cover (using Fig. 2) of each of (where present):

- crop residues; being the materials left in the field, lying (horizontally) on the soil surface either after harvesting and in-field processing of crops, or a cover crop laid-flat with a knife roller
- crop stubble; being the standing stubble of a harvested (or mowed) crop
- standing (living) cover crops.

In certain circumstances, the percent cover of stone mulches may also be recorded.

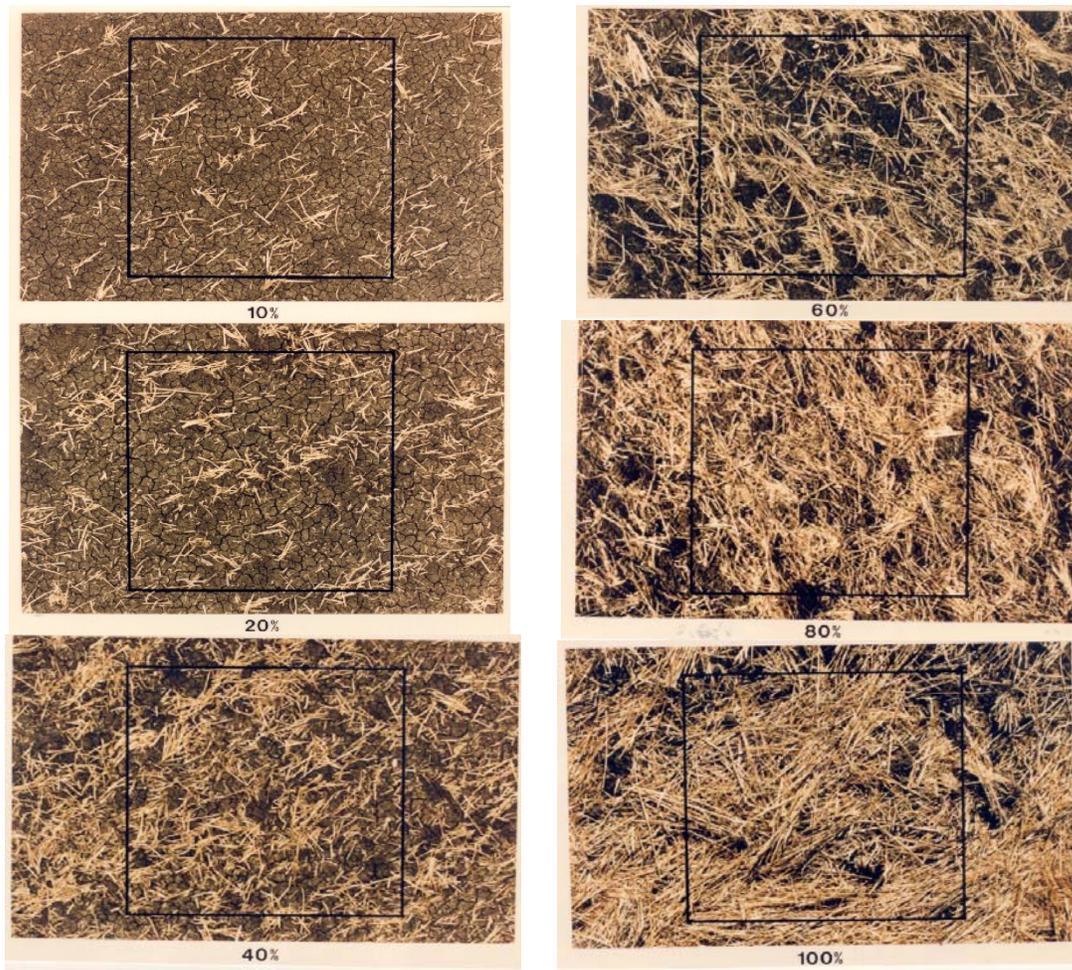


Fig. 2 Photo-standards to assess percentage cover of crop residues. Examples of wheat residues (on a black soil) are presented for each of: 10, 20, 40, 60, 80 and 100%. (from Molloy 1988). Crop residues and stubble are vital to maximising moisture storage, and reducing water runoff and soil erosion.

A 5. Site photo or sketch

Take a photograph (or sketch) of the landscape around the site and of important surface features. Both “landscape” and vertical (as in Fig. 2) photos / sketches are useful.

B. Digging the hole

1. Spade technique
2. Hole size and depth

The morphological (soil visual) descriptions (described in section C, below) will be primarily based on the evaluation of a block of soil removed by a spade. The spade technique is described in the SOILpak manual (McKenzie 1998). Essentially, a spade with a flat (though usually slightly curved) blade is used to remove an intact “block” of soil, commonly up to 30 or 40 cm deep and 25 cm wide. The soil is left on the blade of the spade for subsequent observations. The spade, with the block of soil on the blade, is commonly “propped-up” on a rock or against a car or fence for description, sketch or photograph.

The soil zones of greatest interest in terms of VS-Fast occur from the soil surface to approximately 40 cm depth. This represents the most important zone for seedbed development, early germination and plant growth, as well as being the zone with the greatest potential for negative impacts on water infiltration, soil carbon losses, etc from soil compaction and erosion (both wind and water).

C. Soil visual descriptors

1. Soil depths
2. Soil structure
 - a. type, size, grade and consistency
 - b. tillage pan
 - c. aggregate size distribution
3. Soil texture
4. Soil colour
5. Roots
6. Photo or sketch

C 1. Soil depths

Firstly, using a measuring tape, ruler or stick graduated in centimetres, assess and measure the location of any visible soil layers; in terms of colour, soil structure (see below), root density, etc.

RECORD these depths.

C 2. a. Soil Structure: type, size, grade and consistency

Soil structure reflects the way in which individual soil particles clump, bind or aggregate together. Natural aggregates that can be clearly seen in the field are called "peds". Clods, on the other hand, are aggregates that are broken into shape by artificial actions such as tillage. Structure is very important since (along with texture) it affects the pore space of the soil. A dense structure will greatly reduce the amount of air and water than can move freely through the soil. Also, it will affect "root penetration" or the plant's ability to propagate roots through the soil.

There are four features that may be recorded in the field to describe and define soil structure

1. **Type** of pedality provides a description of ped shape. There are five major types of structure: granular, blocky, platy, prismatic and structureless (or massive) (Fig. 3).

Granular, or crumb structures, look like cookie (biscuit) crumbs. They tend to form a more open structure that allows water and air to penetrate the soil. Platy structures look like stacks of dinner plates overlaying one another. Platy and massive structure tends to impede the downward movement of water and plant roots through the soil. Therefore, open structures tend to be better agricultural soils

2. **Size** is the average least dimension of peds, used to define class intervals, eg small (0-2 mm), medium (2-5 mm), etc.
3. **Grade** is the degree of development and distinctness of peds, used to express the relative difference between the strength of cohesion within peds and the adhesion between adjacent peds.

***NOTE:** Grade is highly dependent on current water content. So, it is important that soil water content is similar between soils being described and*

compared. Alternatively, state the soil water content at time of conducting the test (dry, moist, wet, etc)

Terms used:

- (a) none: ie the soil is single grain (a sand) or massive
- (b) weak: poorly formed aggregates
- (c) moderate: well formed aggregates, visible in the disturbed soil
- (d) strong: very well formed aggregates that are quite clear

4. **Consistency** describes the “feel” of the soil, reflecting relative resistance to pressure (Fig. 4). The terms are used to describe the soil to mechanical stresses or manipulations.

NOTE: *Consistency is highly dependent on current water content. So, it is important that soil water content is similar between soils being described and compared. Alternatively, state the soil water content at time of conducting the test (dry, moist, wet, etc)*

Terms used:

- (a) loose
- (b) friable
- (c) firm
- (d) extremely firm

To determine the type, size, grade and consistency of structure:

- As described by Batey (personal communication): “Begin at the original surface (of the intact material on the spade) and break the spadeful of soil gently apart by hand. The criteria used are the size, shape, porosity and cohesion of aggregates and lumps. The assumptions made are that fine and medium crumb-sized aggregates and (large amounts of) porosity ...are beneficial to root development and crop growth. Overall, the test assesses the quality of the soil as a medium for root growth.”

As the soil is gently manipulated, observe the components specified in Figs. 3 and 4.

RECORD all observations in terms of type, size, grade and consistency of structure.

C 2. b. Soil Structure: tillage pan

Recording the presence and degree of development of a tillage pan is a continuation of the use of the above descriptors of the type, size, grade and consistency of soil structure. In these terms, tillage pans are located and described by comparing the lower and upper parts of the excavated spadeful of soil. As an example, the upper layer may be small to medium granular structure, overlying a tillage pan, described as “massive or platy” with the thickness recorded. However, VS-Fast specifically records and scores the presence/degree of a tillage pan, recognising it as both an important negative indicator of soil condition as well as being symptomatic of non-sustainable land management practices.

Tillage pans form as a result of tillage and ploughing in conventional (plough-based) farming systems. The top layers of the soil (generally to 15 or 20 cm depth) are

mechanically loosened but the layer immediately beneath is consolidated (compacted) from the downwards pressures of the metal implement. Tillage pan formation, and the degree of compaction in particular, is maximised both with repeated passes of implements (ie with time) and by cultivating moist – wet soil which has low strength and is readily deformed (compacted).

Well-developed tillage pans impede the movement of water, air and plant roots through the soil (Shepherd 2000). The cumulative effects include increased risk of water logging (as water tends to lie on top of the compacted pan) and erosion (as the loosened topsoil can be readily detached from the compacted subsoil) as well as yield reductions and crop losses (through shallow and “right-angle” root systems, less able to survive dry periods).

RECORD the presence and degree of development of a tillage pan

Scoring (after Shepherd 2000):

1. Good condition (score = **2**): no tillage pan, with friable structure and soil pores from topsoil to subsoil
2. Moderate condition (score = **1**): firm, moderately developed tillage pan in the lower topsoil (or upper subsoil), clearly platy or massive but containing one or more of: areas of soil structure recorded above or below the pan, cracks or continuous pores
3. Poor condition (score = **0**): a well developed tillage pan in the lower topsoil (or upper subsoil), with massive or platy structure with firm to extremely firm consistency and very few or no vertical cracks or pores

Soil Structure

Soil structure is the shape that the soil takes based on its physical and chemical properties. Each individual unit of soil structure is called a **ped**. Take a sample of undisturbed soil in your hand (either from the pit or from the shovel or auger). Look closely at the soil in your hand and examine its structure. Possible choices of soil structure are:

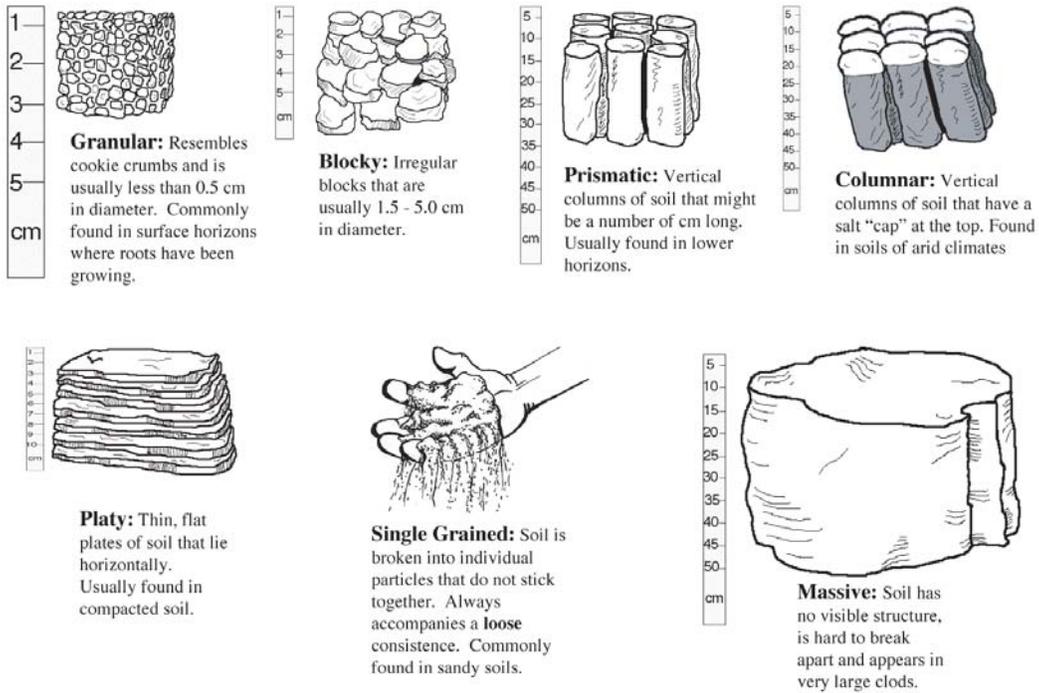


Fig. 3 Examples of the different types of soil structure. In this diagram, all of the soil structures shown have "strong" grade of structure, that means the structure shape is readily seen (from NASA 2004).

Soil Consistence

Take a **ped** from the top soil horizon. If the soil is very dry, moisten the face of the profile using a water bottle with a squirt top and then remove a **ped** to determine consistence.

Holding it between your thumb and forefinger, gently squeeze the **ped** until it "pops" or falls apart. Record one of the following categories of soil consistence on the data sheet. (Repeat this procedure for each horizon in your profile.)



Fig. 4 The determination of soil consistence (the strength of the soil) (from NASA 2004).

C 2. c. Soil Structure: aggregate size distribution

In order to bring some uniformity to the method of manipulating the soil (on the spade) and to get it to break along natural cleavage planes, Shepherd (2000) has further developed the “drop-shatter” test. In this, a spadeful of soil is dropped three times from a uniform height either onto a plastic sheet (lying on the ground) or into a rectangular shaped “washing-up” basin. If the soil does not completely shatter into individual units, then gentle hand manipulation is used to break the soil along natural breakage lines. Once the soil is broken into its individual aggregates, these are sorted so that the smallest are placed at the top and the coarsest at the bottom (Fig. 5).

As such, this is a field method of aggregate size distribution. Degraded soil tends to have more coarse structure units than a well structured soil (Fig. 5).

One problem with this test is the strong interdependency between what is achieved with the “drop test” and the current soil water content. The wetter the soil, the less will be achieved when the soil is dropped. Every effort should be made to conduct comparisons at the same water content. Another problem occurs in sandy soils where the aggregates cannot be sorted by hand due to their inherent weakness (ie the structure grade is “weak”). In that situation the test is not conducted but the structure type, size, grade and consistency are recorded (as in C 2.a.) above.

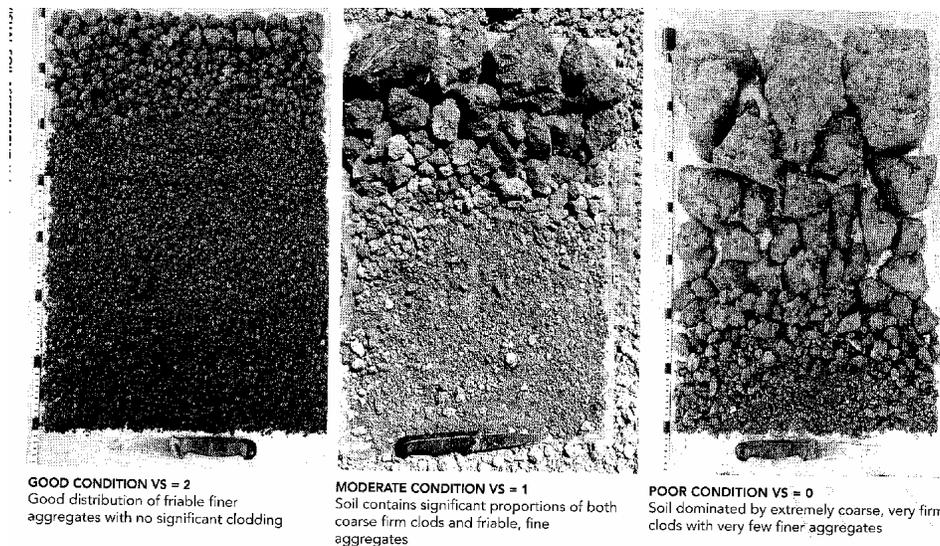


Fig. 5 Examples of (left) finely structured soil and (right) coarsely aggregated soils; differentiated using the “drop-shatter” test with subsequent arrangement into coarse – fine aggregate size distribution (from Shepherd 2000).

Scoring (after Shepherd 2000):

1. Good condition (score = **2**): good distribution of friable, smaller aggregates with no significant number of clods
2. Moderate condition (score = **1**): soil contains significant proportions of both large, firm clods and friable, small aggregates
3. Poor condition (score = **0**): soil dominated by large, extremely firm clods with very few small, friable aggregates

C 3. Soil texture

Soil texture refers to the relative proportions of sand, silt and clay size particles in a sample of soil.

- Clay size particles are the smallest being less than 0.002 mm in size.
- Silt is a medium size particle being between 0.002 and 0.05 mm in size.
- The largest particle is sand with diameters between 0.05 for fine sand to 2.0 mm for very coarse sand.

Texture has important effects on a soil's water holding capacity, aeration and porosity, hydraulic conductivity, compaction potential, resistance to root penetration, nutrient holding capacity (i.e. cation exchange capacity) and resistance to acidification (Moody in press)

Soils that are dominated by clay are called fine textured soils while those dominated by larger particles are referred to as coarse textured soils. Soil scientists group soil textures into soil texture classes (Fig. 6).

Field method:

Texture can be determined in the field by taking one or two table-spoonfuls of soil in one hand and adding water, drop by drop, to the soil as it is being worked in the hand until a sticky consistency is reached (Moody in press). The soil is then rolled into a ball and texture determined by reference to Table 1 and Fig. 7.

RECORD the texture class determined, on the field sheet

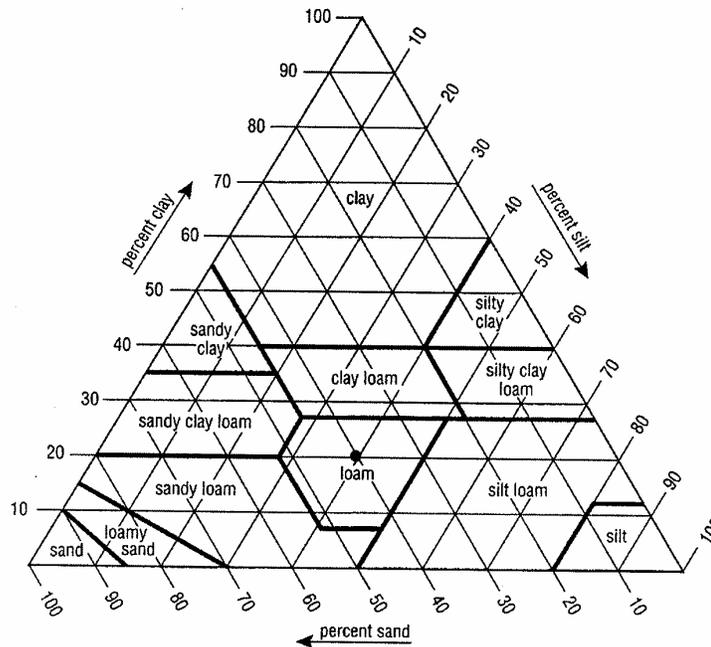


Fig. 6 Soil texture diagram showing the % of sand, silt and clay in the textural classes

Table 1 To determine the textural class the soil belongs to, compare it to the table below and to the diagrams in Fig. 7. Source: Rural Development in the Tropics and Subtropics (1989).

Sandy	The soil stays loose and separated, and can be accumulated only in the form of a pyramid	Figure A
Sandy Loam	The soil contains enough silt and clay to become sticky, and can be given the shape of an easy - to - take - apart ball.	Figure B
Silty Loam	Similar to the sandy loam, but the soil can be shaped rolling it with a small and short cylinder.	Figure C
Loam	Contains almost the same amount of sand, silt and clay. Can be rolled with a 6" long (approximately) cylinder that breaks when bends.	Figure D
Clayey Loamy	Similar to the loamy, although this one can be bent and be given a U shape (without forcing it) and does not break.	Figure E
Fine Clay	The soil can be given the shape of a circle, but shows some cracks.	Figure F
Heavy Clay	The soil can be shaped as a circle, without showing any crack.	Figure G

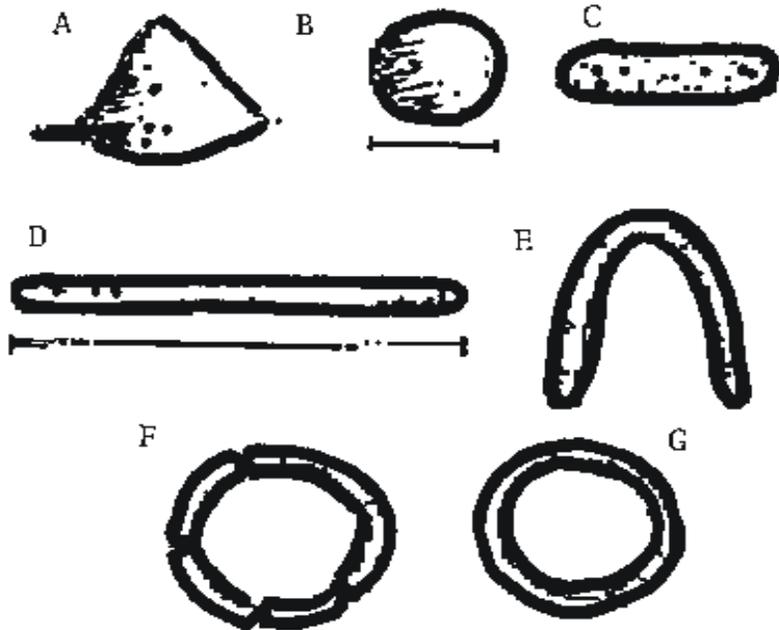
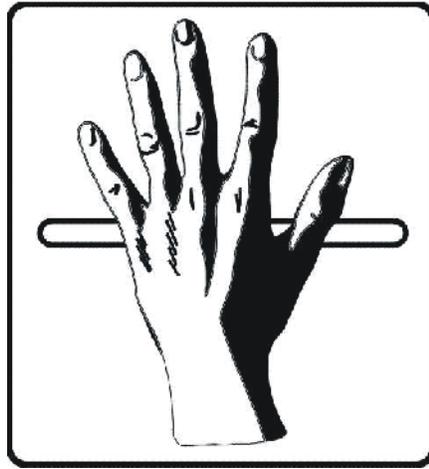


Fig. 7 The point at which the soil becomes malleable and can be hand-shaped, indicates its texture (use in conjunction with Table 1).
Source: Rural Development in the Tropics and Subtropics (1989).

C 4. Soil colour

Soil colour indicates many important soil properties.

First and foremost soil colour provides much information on the source material(s) of the soil and the climatic/human factors that have altered the original rocks and sediments to give the current soil condition.

Secondly, soil colour is a strong indicator of current soil water (or aeration) status. Generally, bright colours, and reds and oranges in particular, show good soil aeration and drainage (the iron in the soil is in the ferrous (oxidised) state). Dull and grey colours show reduced aeration and a tendency for low-oxygen status and waterlogging. The dull grey/black colours in a waterlogged soil often occur as mottles, ie a secondary colour within the main soil colour.

Thirdly, soil colour may reflect the organic matter status of the soil, particularly useful when comparing the topsoils of long term cropping land with treelines and fencelines. Generally, the darker the soil the greater the organic matter content.

How do I measure the soil colour?

1. Take a lump of soil from the layer/horizon to be described. Break the lump to expose a fresh face (Fig. 8).
2. If the soil is dry moisten the face by adding water drop by drop.
3. Wait for the water to seep into the soil.
4. Now name the soil colour, eg red, brown, grey, black, white, etc
5. If a soil has more than one colour. Record a maximum of two and indicate (1) the main (dominant) colour and the (2) secondary colour.
6. *If available*, match the soil with a chip on the Munsell Soil Colour Chart. Record the Soil as: Hue/Value/Chroma value and the name of the colour.

RECORD the soil colour(s) on the field sheet.

Soil Color

1. Take a ped of soil from each horizon and note on the data sheet whether it is moist, dry or wet. If it is dry, moisten it slightly with water from your water bottle.
2. Stand with the sun over your shoulder so that sunlight shines on the color chart and the soil sample you are examining. Break the ped.

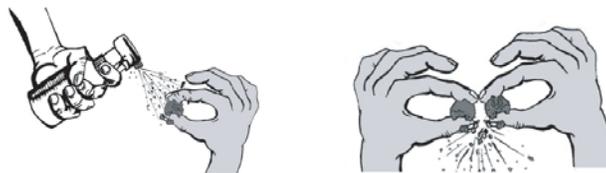


Fig. 8 Procedure of determining soil colour in the field (from NASA 2004).

C 5. Earthworms

Soil biota are the very “life” of the soil. Their presence, in large numbers throughout the soil profile represents two inter-related phenomenon. Not only are the biota excellent indicators of a soil’s general “well-being” but also by their presence and lifestyle they also improve the soil condition. To exemplfy the latter, earthworms are vital to incorporate organic matter into the soil, improve aeration (particularly the all important inter-connected pores) with associated improvements in water infiltration and crust prevention, and increasing soil fertility *via* their caste material.

The presence of large numbers of species in good concentrations reflects and integrates many positive aspects of soil condition: good aeration (no waterlogging), softness (no compaction), plentiful food supply (for earthworms, the retained crop residues and stubble) and the lack of disturbance by cultivation (no-till). As such, the presence of biota is a most important, and fortunately in terms of the macro-biota, a most readily measurable attribute.

Emphasis here will be given to recording the numbers and size of earthworms. The reason is twofold:

1. they are the most discernible and captured form of soil biota and
2. their presence can be interpreted as showing a general soil “well-being” with the inference that if earthworms are present, then other (smaller, less discernible and capturable) biota are also present.

Important, is the recognition that earthworms are seasonal and migratory animals (seeking warmth, food and moisture). Because of this, it may well be that during a soil inspection earthworms are not found but strong evidence of their earlier presence is visible, namely **earthworm burrows** in the soil profile and caste (faecal) material on the soil surface. Hence, in the absence of actually capturing and counting earthworms, note should be taken of the number and concentration of related worm features.

Method:

1. While manipulating the soil on the spade blade for soil structure description, pick-out and place to one side all earthworms found in the soil sample.
2. Be prepared to note the presence (number and size) of earthworm burrows and castes, too.

RECORD earthworm numbers on a square-meter basis. So if the spadeful of soil is a 20cm³, that equates to a 1/25 square metre of soil, so multiply numbers of earthworms by 25 to convert to a m² basis.

Scoring (after Shepherd 2000):

1. Earthworms plentiful (score = **2**) if >8 earthworms counted
2. Moderate earthworm numbers (score = **1**) if 4 to 8 earthworms counted
3. Few earthworms present (score = **0**) if <4 earthworms counted

C 6. Roots

The development of root systems into the soil are a prime biological indicator of soil condition. The root system is actively demonstrating current soil conditions by reacting to it.

The determination is of the size (diameter) and development of the plant root system. This is best done both:

1. by examining the root system emanating from the sides of the cube of excavated soil (on the spade blade), and
2. then similarly as the soil on the spade blade is manipulated and broken up for soil structure description.

Observations (recorded and leading to scoring on the field sheet) will include the following :

1. evidence of acute, sharp changes in root penetration into the soil (the “L” shaped root syndrome, particularly evident in tap rooted crops like cotton and sunflower)
2. disproportionate number and concentration of roots in the immediate surface layer, demonstrating that passage into the layers beneath is difficult
3. concentration of roots on ploughpans – at the greatest depth of ploughing
4. evidence of roots “squashed” between strong soil units, demonstrating their inability to penetrate into these units, and access water/nutrients within, and
5. an absence of fine root hairs, or an over-abundance of strong primary roots, showing the difficulty (and hence loss of vigour) experienced by the fine roots, penetrating the soil.

RECORD observations in the general notes on the field sheet or annotate the photograph or soil profile sketch with root shapes and concentrations.

Scoring (after Shepherd 2000):

1. Good condition (score = **2**): unrestricted root development
2. Moderate condition (score = **1**): limited horizontal and certainly vertical root development
3. Poor condition (score = **0**): severe restriction of horizontal and vertical root development; presence of “L” shaped roots, over-thickening of roots, or roots squashed between soil units

C 7. Photo or sketch

Photograph the soil profile you have removed as it sits on the blade of the spade. Angle the whole spade (and soil profile) to approximately 70 degrees from vertical (placing a piece of timber or rock behind to steady it).

Place a tape measure along the profile so that 0 cm is at the top of the profile to record horizon depths for the picture.

If no tape measure available, ensure part of the spade blade is visible in the photo – to act as a scale after developing and when annotating the photo.

If no camera available, sketch and annotate the soil profile on the field sheet with the most important attributes.

D. Soil measurements

1. Slaking and dispersion
2. Soil pH
3. Water infiltration
4. Organic carbon (labile)

D 1. Slaking and dispersion; soil stability in water

The inherent ability of a soil, and particularly the soil surface, to withstand the impact of several types of land degradation, principally wind and water erosion, is strongly dependent on the soil's response when wetted.

There are two main types of aggregate collapse when water is added to soil: slaking which describes the breakdown of aggregates into microaggregates, and dispersion which describes the breakdown of aggregates into the primary soil particles of sand, silt and clay (Fig. 9).

The differentiation between slaking and dispersion is most important. Generally, the products of slaking can re-form to produce larger aggregates whereas dispersion into primary particles is irreversible and results in undesirable, massive structure. On the soil surface, dispersed soil appears either as a hardsetting layer (or a surface crust) or as loose fine sand grains. Crusts and hardsetting are major impediments to both water penetration (causing rain water to pond on the soil surface with strong potential for erosion) as well as to the germination of seeds. Additionally, fine, loose (dispersed) material on the soil surface has strong potential for wind erosion.

The amount of organic carbon in a soil strongly influences the ability of a soil to maintain aggregation (and not disperse) when wetted. Organic matter binds soil particles together, and particularly in sand and loam soils is the principal material causing aggregation.

The determination of the slaking or dispersive nature of a soil is commonly a laboratory test but an appreciation of the phenomenon can be gained in a short time during soil description in the field (Field et al. 1997).

The procedure is as follows. Drop an air-dried aggregate from the layer under investigation into a dish (e.g. a saucer) or a small clear container (glass or cup) containing water (use rain water or local irrigation water). After each of 10 minutes and 2 hours (when possible) immersion, a visual judgement is made of the degree of dispersion on a scale of 0 – 4 on conclusion of the test (Fig. 9).

NOTE the scoring is the reverse of the Field et al. (1997) scoring, to reflect the fact that the VS-Fast methodology gives a larger score for better conditions.

Scoring:

1. No dispersion (though the aggregate may slake) (score = **4**)
2. Slight dispersion, recognised by a slight milkiness in the water adjacent to the aggregate (score = **3**)
3. Moderate dispersion with obvious milkiness (score = **2**)

4. Strong dispersion with considerable milkiness and about $\frac{1}{2}$ the original aggregate volume dispersed outwards (score = **1**)
5. Complete dispersion, the original aggregate completely dispersed into clay, silt and sand grains (score = **0**)

RECORD the score value on the field sheet

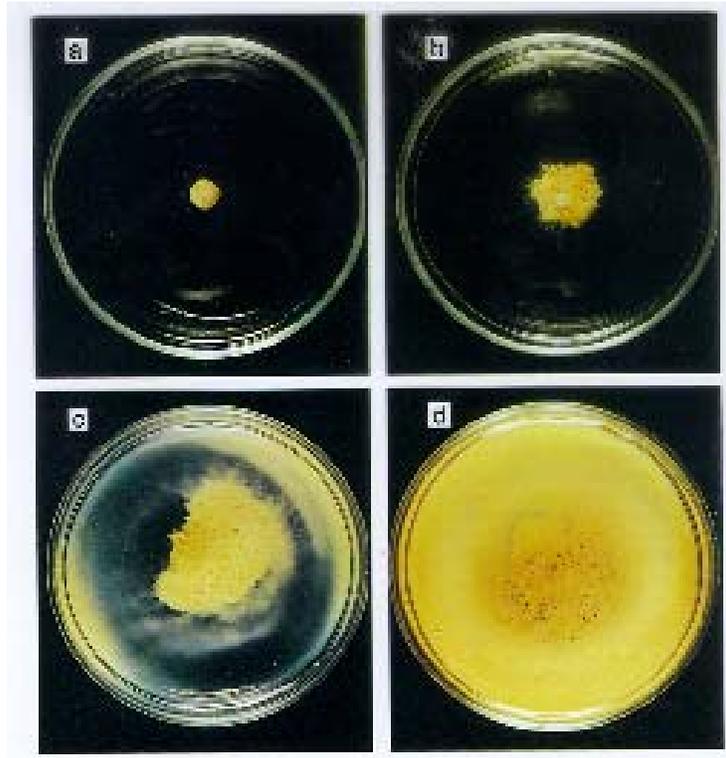


Fig. 9 Examples of the nature and the range of dispersion classes in the soil dispersion test.

Source: McKenzie et al. (1992).

- (a) the aggregate remained intact with no slaking or dispersion [score = 4]
- (b) a slaked aggregate with no dispersion [score = 4]
- (c) the aggregate slaked and partially dispersed [score = 2]
- (d) the aggregate completely slaked and dispersed [score = 0]

D 2. Soil pH

Soil pH measures the molar activity (concentration) of hydrogen ions in the soil solution (Moody in press). It is a negative logarithmic scale, so a decrease of 1 pH unit increases the hydrogen ion concentration ten-fold. At a pH of 7 (neutrality), the activity of hydrogen ions is equivalent to the activity of hydroxyl ions. At pH values less than 7, the soil is acidic, whereas at pH values greater than 7 the soil is alkaline.

In summary, and taken directly from Moody (in press), strongly acidic soils can have the following negative characteristics:

- aluminium and/or manganese toxicity,
- phosphorus deficiency,
- calcium and/or magnesium deficiency,
- reduced nitrogen mineralisation because of restricted microbial activity,
- reduced boron, zinc, molybdenum and copper availability.

Strongly alkaline soils can have the following negative characteristics:

- surface sealing and crusting problems due to excessive sodium,
- reduced availability of iron, manganese, zinc, phosphorus and copper,
- reduced microbial activity and reduction in fungal population.

The pH test presented here utilises a “field test kit” (approximate cost of \$US18). The test kit (Fig. 10) is based on many decades of development by several scientists in CSIRO, Australia. It is the field test kit used by Australian field pedologists (soil surveyors).



Fig. 10 The pH field test kit

The procedure is as follows:

1. Take a small amount of soil from the centre of a layer of interest. Crumb it up and place onto a white tile or piece of flat plastic.
2. Add some of the black/purple liquid from the Test Kit (this is Universal (Raupach) indicator). Mix the soil and the indicator well together with a plastic or wooden rod (a clean stick or old “biro” pen).
3. Just add enough of the liquid to thoroughly moisten the soil (without flooding it).
4. Let the mixture sit for two minutes (to let the two react).
5. Using the little “puffer” bottle, gently “puff” a fine layer of the Barium Sulphate powder over the mix. A colour will develop in the powder.
6. Match this colour with the closest match on the Test Kit colour chart.

RECORD the pH value on the field sheet. This is commonly recorded to 0.5 of a unit accuracy.

D 3. Water infiltration

A major determinant of the cropping or grazing potential of a soil is the rate and amount of water that can infiltrate either through the soil surface or within the soil profile. Bagarello and Sgroi (2004) state that saturated hydraulic conductivity (water infiltration) is recognised as “one of the most important soil properties” that controls a wide range of inter-related soil properties that directly impact on land and environmental quality. These include water infiltration, soil profile re-fill, surface runoff, leaching of pesticides and migration of pollutants from contaminated sites to groundwater (Bagarello and Sgroi 2004).

Especially for structured soils, saturated hydraulic conductivity has to be measured directly in the field in order to minimise disturbance of the sampled soil volume and to maintain its functional connection with the surrounding soil (Bagarello and Sgroi 2004). Removing soil from the field, commonly in a variety of diameters of plastic and metal rings, has strong potential to truncate soil pores (holes), cut by the sidewalls of the sample ring. Non-representative data results.

The following method has been devised by Dr Freeman Cook, CSIRO, Australia. The aim was to derive a simple method for the rapid estimation of soil hydraulic conductivity. Simplicity, both in apparatus required and field method, was essential. However, though operationally simple, the method is **robust**, being firmly based on fundamental, globally tested and accepted soil physical principles.

The method considers two scenarios:

- in the first, the ring is only pressed a short distance (a few millimetres) into the soil surface (this facilitates 3 dimensional flow – where the water can flow both vertically and horizontally into the soil), and
- in the second, the ring is pushed in to a considerable depth (> diameter of ring), so that the flow is essentially 1 dimensional (ie the water mostly flows vertically into the soil).

Dr Cook advises that, when possible, always use the 3-D method as results will be obtained more quickly and the time data is more sensitive to the hydraulic conductivity. The 1-D method is more appropriate when soil cracking or the aggregation of the soil makes it difficult to seal the ring onto the soil without leaks occurring.

Field equipment is a 100 (length) x 100 mm (diameter) ring (metal or PVC with a sharpened tip), a container holding exactly 50 mm of water and a watch.

The method is: rapidly (but aiming to minimise the pouring height and speed of the water hitting the soil surface) add the water, to the soil surface inside the ring. Note the time for the water to disappear (infiltrate) into the soil.

Tables 2 and 3 present summary hydraulic conductivity data for each of the 3-D and 1-D scenarios, respectively.

RECORD whether 1-D or 3-D infiltration was measured and “fast”, medium” or “slow” rate using the times in Table 2.

Scoring (from Tables 2 and 3):

1. Fast rate (score = **2**)
2. Medium rate (score = **1**)
3. Very slow rate (score = **0**)

Table 2. Simple estimation of *K* on the basis of 3-D flow from a pond.

Time for 50 mm of water to be gone from ring with radius 50 mm.	Hydraulic conductivity - <i>K</i> (mm/hr)	VS-Fast score
< 10 min	> 36 (fast)	2
>10 min, < 2 hr	> 3.6 (medium)	1
> 2 hr	< 1 (very slow)	0

Table 3. Simple estimation of *K* on the basis of 1-D flow from a pond.

Time for 50 mm of water to be gone from ring with radius 50 mm.	Hydraulic conductivity – <i>K</i> (mm/hr)	VS-Fast score
< 30 min	> 36 (fast)	2
>30 min, < 10 hr	> 3.6 (medium)	1
> 10 hr	< 1 (very slow)	0

D 4. Soil organic carbon – labile fraction¹

Most of the functions associated with soil quality are strongly influenced by soil organic matter, especially the small portion that is termed active organic carbon (Weil WWW site). Organic carbon is known to rapidly decrease with cultivation and cropping and its loss is known to have a deleterious effect on other important soil properties such as leading to increased aggregate strength and bulk density, decreased water infiltration and water holding capacity and decreased aggregate stability (Li et al 2004; Matson et al 1997). As an example a 38% loss of soil organic carbon was measured in the sandy grasslands of the Horqin Sandy Land of northern China after only 3 years of cultivation (Su et al 2004). Associated with this decline, soil structure also deteriorated, wind erosion increased and nutrient levels decreased (carried away in the wind-eroded fine fractions). This accumulation of effects was regarded as most deleterious in the nutrient poor soils of the region (Su et al 2004). Soil organic matter is also known to be critical in providing the organic substrate that regulates nutrient availability and release (Matson et al 1997).

Decline in levels of soil organic matter is reversible and in fact several studies have shown levels can be increased. In practice, this is achieved through the many management strategies that fall under the descriptor of “sustainable agriculture” (Matson et al 1997). These include no- or minimal-till, the use of cover crops, green manures, and the use of better yielding varieties (returning more organic materials to the soil). Concomitant with the increased organic status are increases in soil fertility, water infiltration and water holding capacity. As an example, McGarry and Sharp (2003) measured 47% more organic carbon in the 20-30 cm layer of a field that had been under no-till for 12 years, relative to an immediately adjoining conventionally tilled field. The difference continued to the 50-60 cm layer where there was 40% more organic carbon in the no-till field. These differences were matched with a measured 23% decrease in bulk density of the 0-5 cm layer and a x45 increase in water infiltration on the soil surface, in the no-till field.

Most (routine) soil chemical laboratories provide a determination of total soil organic matter or soil organic carbon (SOM and SOC). This is reported as something generally between 0.5% and 7% in soil. These cannot be field tests as they are based either on total (high temperature) combustion of a soil sample or require strong chemical reagents. Another problem is that they are insensitive to management practices because they include recalcitrant (inert) forms of organic matter (such as charcoal) which remain unchanged for decades, regardless of management practices.

Techniques have developed to fractionate carbon on the basis of lability (ease of oxidation), recognising that these subpools of “active” carbon may have greater effect on soil physical stability and be more sensitive indicators of carbon dynamics in agricultural systems than total carbon values (Weil et al. 2003). Additionally, comparisons of never-cropped land and adjoining farmland across several soil types, have reported a substantial loss of carbon with cropping and in particular the labile (permanganate oxidisable) carbon. The labile fraction of soil carbon is the component of organic matter that feeds the soil food web and is closely associated with nutrient cycling and other important biological functions in the soil.

¹ Part of this text is adapted from an article in the “New Farm” (The Rodale Institute, USA) on-line magazine; : http://www.newfarm.org/columns/ray_weil/0103.shtml

Weil et al. (2003) have developed a “field kit method” for the determination of potassium permanganate (KMnO₄) oxidisable Carbon. In this test a dilute solution of KMnO₄ is used to oxidize organic carbon. Generally, in the course of the experimental procedure the greater the loss in colour of the KMnO₄, the lower the absorbance reading will be, hence the greater the amount of oxidisable Carbon in the soil.

In the longer term, the aim is to reduce the required technology (the hand-held colorimeter, costing \$US300-400) by replacing it with a range of colour (purple) chips – to represent the range of results found in field soils.

The method requires a field kit consisting of:

- a stock solution of 0.033 molar (33 mM) solution of potassium permanganate in 1 M CaCl₂ (at pH 7.2) (with an approximate ratio (by volume) of 25:1; KMnO₄ to CaCl₂)
- a palm-sized spectrometer (for example a Hach (or generic) 550nm) for gauging the change in colour (the optical density) of the potassium permanganate
- screw top tubes for shaking the soil suspension
- measurement pipettes
- a scoop for measuring soil (five cc capacity)

The procedure is as follows:

- calibrate the colorimeter using varying concentrations of the stock solution (Fig. 11)
- sun- or air-dry 20 g of the soil under investigation for 15-30 minutes
- in one of the tubes mix five cc of the crumbled soil with the stock solution,
- shake vigorously for exactly two minutes
- stand upright for 5-10 minutes, protected from direct sunlight
- zero the colorimeter with a sample of distilled water
- pipette-off 0.5 ml of liquid from the top 1 cm of the “soil sample” mix
- add it to 45ml of distilled water, top up to 50 ml
- mix well, then put 15 ml of this solution into the measuring cuvette (of the colorimeter)
- place the cuvette in the colorimeter, put on the cover and press “read”
- the spectrometer will measure the colour of the potassium permanganate solution

Read the colorimeter digital display and use to:

- calculate active carbon using the calibration line (Figs. 11)

RECORD the amount of active carbon present (mg/g) using Fig. 12.

Scoring (from Table 4 and dependent on soil texture):

1. Good organic matter status (score = **2**)
2. Moderate organic matter status (score = **1**)
3. Poor organic matter status (score = **0**)

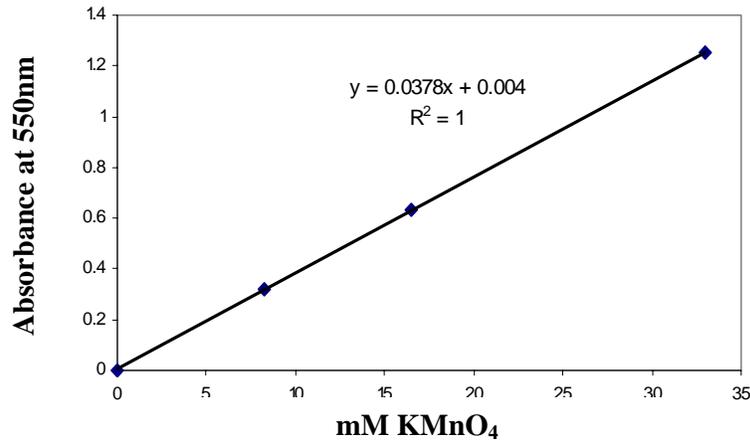


Fig. 11 Standard calibration curve of four strengths of 33 mM KmnO₄ (x – axis) with colorimeter read-out (y – axis).

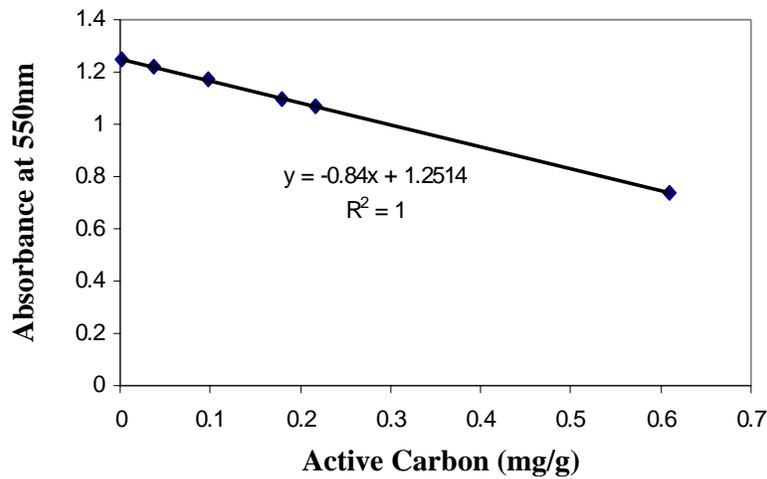


Fig. 12 Relationship between the colorimeter readout and the amount of labile (“active”) Carbon (mg/g) based on the 6 samples from Fenging County, China.

Table 4 Permanganate (33 mM) oxidisable carbon contents (mg/g) considered to be low, moderate and high for soils of various textures.*

Soil organic carbon status	Sand	Sandy loam	Loam	Clay loam/Clay
“good”	> 1.0	> 1.4	> 1.8	> 2.0
“moderate”	0.5 - 1.0	0.7 - 1.4	0.9 - 1.8	1.2 - 2.0
“poor”	< 0.5	< 0.7	< 0.9	< 1.2

* Values (mg/g) of labile carbon considered to be “good”, “moderate” and “poor” for soils of different textures. The table is taken from Moody (in press) and the values are based on several hundred laboratory-based organic matter determinations by that author.

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Appendix A Methods used to describe and evaluate the physical condition of soil in the field (from Batey personal communication)

1. Direct field assessment of soil physical conditions: T Batey
2. The visual assessment of soil structure in the field (The Peerlkamp Scale): T Batey
3. SOILpak method for assessment of soil conditions: DC McKenzie
4. A guide to tillage management based on surface soil types: J Lawrie, B Murphy and I Packer
5. Visual soil assessment (VSA): TG Shepherd
6. Soil Quality Management System (SQMS): M Beare
7. Le profil cultural: Morphological characterisation of cultivated structure at the field scale: H Boizard, G Richard & J Roger-Estrade
8. Soil quality scoring procedure: BC Ball & JT Douglas
9. Visual soil assessment - spade analysis: LK Munkholm
10. Assessment of soil structure by visual classification of aggregates: P Weisskopf
11. Visualise your soil (BIZ) - from observation to management: CJ Koopmans, J Bokhorst & E Herres

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date:

Land Use (Current and Past):

Site Location:

Recent Weather Conditions:

Soil Type:

Soil Structure:

Soil Texture:

Soil Colour:

“Walk in” Observations (soil / crop residues):

Soil Profile Sketch

Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan		x 3	
Aggregate Size Distribution		x 3	
Earthworms		X 2	
Roots		x 3	
Ranking Score (Sum of VS-Fast rankings)			<input style="width: 50px; height: 20px;" type="text"/>

Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS)* 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion		(scores: 0-4)	x 1.5	
Soil pH		Not scored	Not scored	-
Water Infiltration			x 3	
Organic C – labile fraction			x 2	

* These scores not applicable to Slake/Dispersion test, where scores range from 0 to 4 (hence ½ weighting value)

Measurements Score:

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5 – 10
Good	11 - 16

TOTAL VS-Fast score:

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...

Appendix C Six International Examples of the Application of VS-Fast
Example: 1 Argentina; site 1a: a never-cultivated or grazed treeline

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date: March 2000

Land Use (Current and Past): Never cultivated or grazed treeline

Site Location: "La Corona", Carlos Casares, BA (300 km SWW of Buenos Aires).

Recent Weather Conditions: dry

Soil Type: Chernozem

Soil Structure: a rich organic layer over a strong, fine to medium blocky structure (dry soil)

Soil Texture: silt-loam

Soil Colour: very dark brown to black

"Walk in" Observations (soil / crop residues): deep organic mulch with good grass growth

Soil Profile Sketch

(see photo over page)

Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan	2	x 3	6
Aggregate Size Distribution	2	x 3	6
Earthworms	2	X 2	4
Roots	2	x 3	6
Ranking Score (Sum of VS-Fast rankings)			22

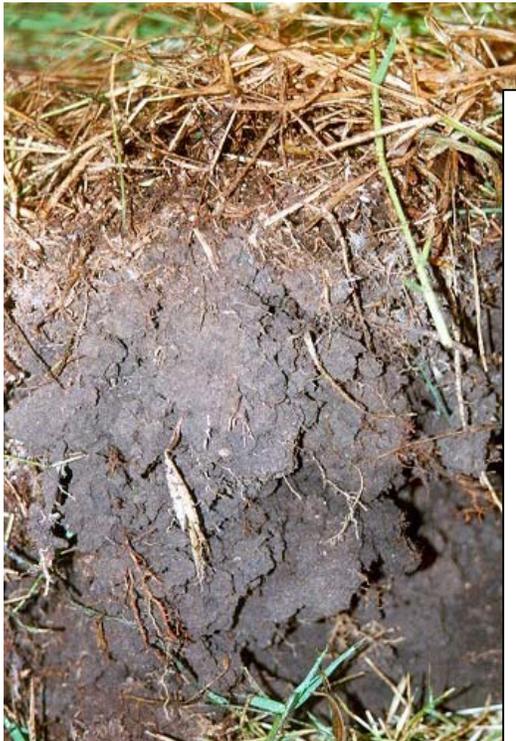
Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion	Not measured		x 1.5	-
Soil pH	Not measured	Not scored	Not scored	-
Water Infiltration	Not measured		x 3	-
Organic C – labile fraction	Not measured		x 2	-

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5– 10
Good	11 - 16

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...



“An organic-rich, dark, well structured soil with abundant, deep penetrating root system”

Example: 2 Argentina; site 1b: no-till field adjoining the treeline (1a, above)

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date: March 2000

Land Use (Current and Past): 12 years of no-till, site adjoins treeline of 1b

Site Location: "La Corona", Carlos Casares, BA (300 km SWW of Buenos Aires).

Recent Weather Conditions: dry

Soil Type: Chernozem

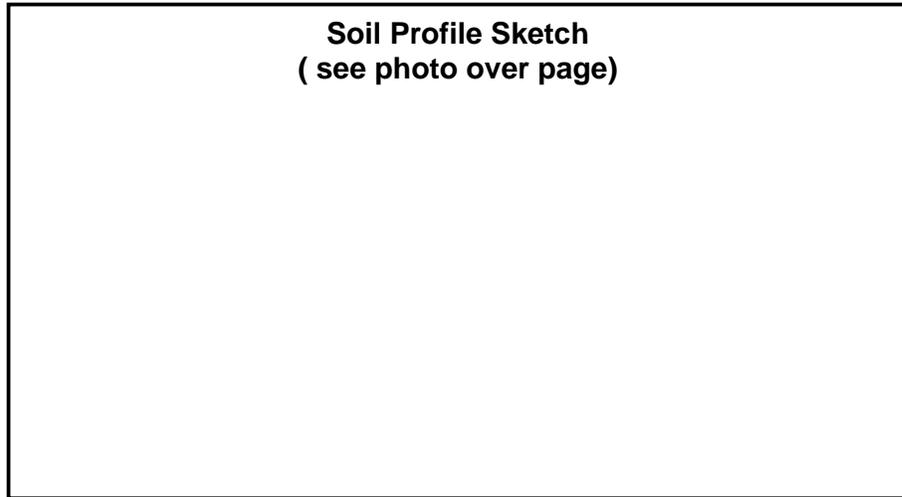
Soil Structure: strong platy structure to 20 cm depth; at least four platy layers evident, then massive soil structure from 20–30 cm (dry soil)

Soil Texture: silt-loam

Soil Colour: light brown to grey

"Walk in" Observations (soil / crop residues): thin organic mulch; many wheel tracks evident

Soil Profile Sketch
(see photo over page)



Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan	0 (not tillage pan; rather "wheel -pan")	x 3	0
Aggregate Size Distribution	0.5	x 3	1.5
Earthworms	2	X 2	4
Roots	1.5	x 3	4.5
Ranking Score (Sum of VS-Fast rankings)			10

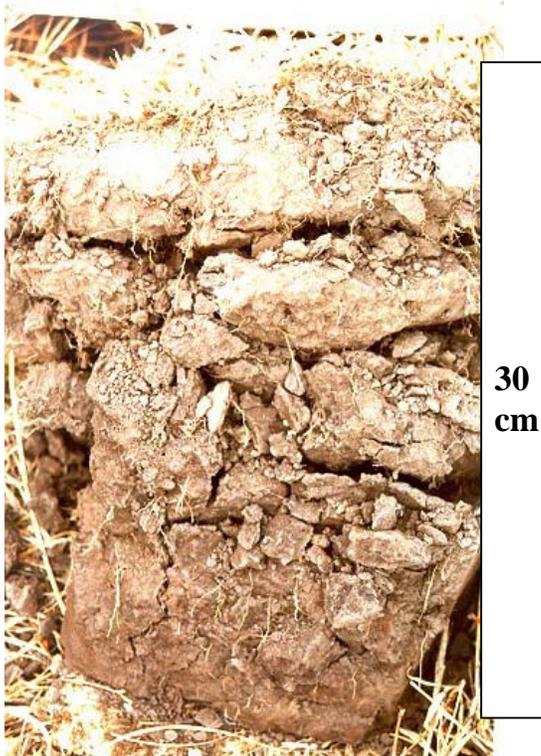
Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion	Not measured		x 1.5	-
Soil pH	Not measured	Not scored	Not scored	-
Water Infiltration	Not measured		x 3	-
Organic C – labile fraction	Not measured		x 2	-

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5 – 10
Good	11 - 16

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...



Immediately adjoining field to the treeline in site 1 a, shows dramatic decline in organic matter as well as very poor structure from repeated random wheelings (despite being zero till).

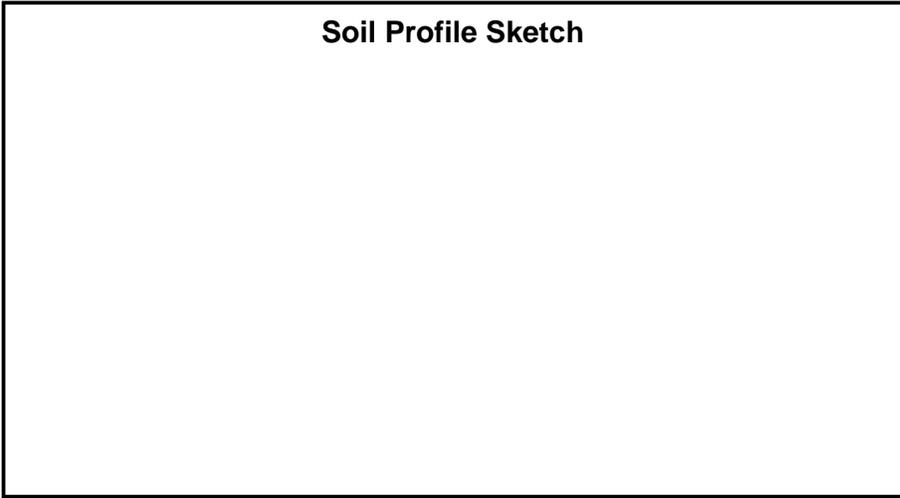
NOTE: Root penetration to depth is not as restricted as expected, because the roots utilise the many earthworm burrows in this soil.

Strong visual differences between these two adjoining sites reflected in their VS-Fast scores:
treeline: 22 (the max. value)
field: 10 ("moderate condition")

Example: 3 Brazil; site 2a: a field that has been under 20+ years of no-till

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date: August 2003

Land Use (Current and Past): 20+ years of no-till; been under pasture phase for 3 years
Site Location: The farm of Herbert Bartz, "Fazenda Rhenania", Rolandia, Parana, BRAZIL
Recent Weather Conditions: dry
Soil Type: Ferrosol ("Terra Rossa")
Soil Structure: strong, fine crumb structure to 12 cm, then fine to medium blocky structure to at least 30 cm
Soil Texture: clay
Soil Colour: deep red to brown
"Walk in" Observations (soil / crop residues): excellent soil cover (100%) of residues and growing pasture; fine soil crumb-structure evident on immediate surface.



Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan	2	x 3	6
Aggregate Size Distribution	2	x 3	6
Earthworms	2 (evident as macropores and castes)	X 2	4
Roots	2	x 3	6
Ranking Score (Sum of VS-Fast rankings)			22

Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion	Not measured		x 1.5	-
Soil pH	Not measured	Not scored	Not scored	-
Water Infiltration	Not measured		x 3	-
Organic C – labile fraction	Not measured		x 2	-

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5 – 10
Good	11 - 16

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...



30
cm

“ A soil in excellent condition. Soil structure corresponds well to the natural (uncultivated and non-trafficked) nature of these soils. Totally un-interrupted root growth to depth. Note that this soil has been under permanent (and profitable) production for at least 20 years, yet is still in very good condition.

Example: 4 Brazil; site 2b: a wheel track in a no-till field adjoining site 2b(above)

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date: August 2003

Land Use (Current and Past): 20+ years of no-till; currently growing wheat

Site Location: The farm of Herbert Bartz, "Fazenda Rhenania", Rolandia, Parana, BRAZIL

Recent Weather Conditions: dry

Soil Type: Ferrosol ("Terra Rossa")

Soil Structure: strong platy structure to 10 cm, then large blocky structure to 20 cm. Beneath 20 cm the soil structure is as good as in site 1a at the corresponding depth; fine to medium blocky

Soil Texture: clay

Soil Colour: deep red to brown

"Walk in" Observations (soil / crop residues): excellent soil cover (100%) of residues and current wheat crop; strong, massive soil structure evident on immediate surface.



Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan	2	x 3	6
Aggregate Size Distribution	0.5	x 3	1.5
Earthworms	1	X 2	2
Roots	0.5	x 3	1.5
Ranking Score (Sum of VS-Fast rankings)			11

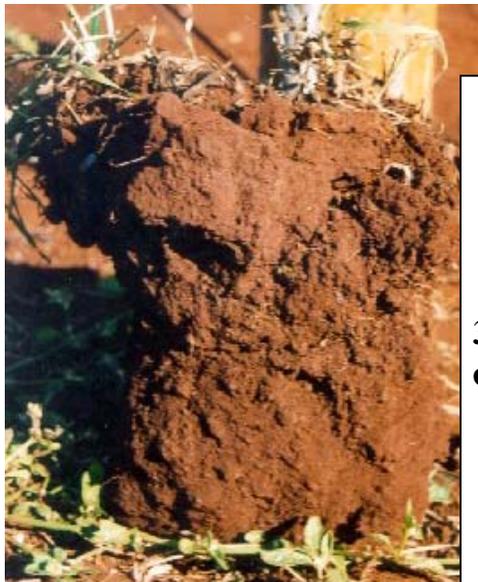
Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion	Not measured		x 1.5	-
Soil pH	Not measured	Not scored	Not scored	-
Water Infiltration	Not measured		x 3	-
Organic C – labile fraction	Not measured		x 2	-

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5 – 10
Good	11 - 16

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...



30
cm

This soil demonstrates that compacted wheel tracks occur in no-till fields. This example is from a spray-rig used to spray insecticide. Note the compaction extends to only 20 cm and the soil structure is good (and similar to site 2a, above) below that. In the platy layer all roots were severely restricted to between the large, massive soil structure units. There was a very obvious crop response to this compaction; the crop being 20 cm shorter and much yellower than the adjoining (not in wheel tracks) crop.

Strong visual differences between these two adjoining sites reflected in their VS-Fast scores:
 pasture field: 22 (the max value)
 field: 11 (“moderate condition”)

Example: 5 Uganda; site 3a: a never cultivated soil in a treeline, Jinja, Uganda

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date: June 2002

Land Use (Current and Past): Never cultivated or grazed treeline

Site Location: in a treeline on a small scale, conventional farm, east of Jinja, Uganda

Recent Weather Conditions: dry

Soil Type: Chromosol

Soil Structure: a rich organic layer to 5 cm over a strong very fine crumb structure, below 12 cm fine to medium weak blocky structure to at least 30 cm (dry soil)

Soil Texture: fine sand -loam

Soil Colour: very dark brown

“Walk in” Observations (soil / crop residues): deep organic mulch on soil surface; soil very soft

Soil Profile Sketch

(see photo over page)

Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan	2	x 3	6
Aggregate Size Distribution	2	x 3	6
Earthworms	2	X 2	4
Roots	2	x 3	6
Ranking Score (Sum of VS-Fast rankings)			22

Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion	Not measured		x 1.5	-
Soil pH	Not measured	Not scored	Not scored	-
Water Infiltration	Not measured		x 3	-
Organic C – labile fraction	Not measured		x 2	-

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5 – 10
Good	11 - 16

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...



“An organic rich, dark, well structured soil with abundant, deep penetrating roots system”

Example: 6 Uganda; site 3b: a ploughed field, Jinja, Uganda

FIELD SCORE CARD
Soil Condition Assessed using VS-Fast Methodolgy
Part A: Soil Visual Descriptors
Date: June 2002

Land Use (Current and Past): a routinely ploughed (oxen and single mouldboard) field, site adjoins treeline of 3b

Site Location: a routinely ploughed field on a small scale, conventional farm, east of Jinja, Uganda

Recent Weather Conditions: dry

Soil Type: Chromosol

Soil Structure: massive (structureless) soil to 12 or 15 cm (the ploughed zone), that overlies weak to moderate platy structure to 25 cm with large, weak blocky structure beneath

Soil Texture: fine sand -loam

Soil Colour: light brown

“Walk in” Observations (soil / crop residues): structureless (soft and powdery) top soil due to recenr ploughing. Soil very light colour compared to treeline.

Soil Profile Sketch
(see photo over page)

Visual Indicator of Soil Quality	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Tillage pan	0	x 3	0
Aggregate Size Distribution	0.5	x 3	1.5
Earthworms	0	X 2	0
Roots	0.5	x 3	1.5
Ranking Score (Sum of VS-Fast rankings)			3

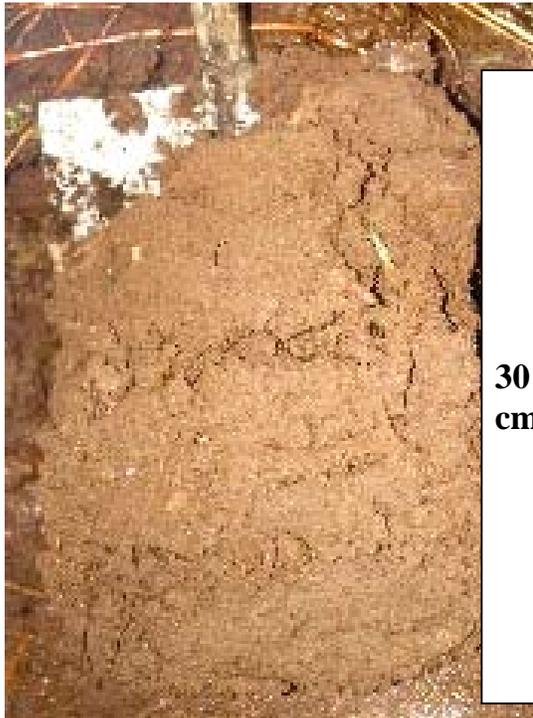
Soil Quality Assessment	VS-Fast Score
Poor	< 7
Moderate	7 – 14
Good	15 - 22

Part B: Field Soil Measurements

Field Measurement	Actual Value	Visual Score (VS) 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast Ranking
Slaking and Dispersion	Not measured		x 1.5	-
Soil pH	Not measured	Not scored	Not scored	-
Water Infiltration	Not measured		x 3	-
Organic C – labile fraction	Not measured		x 2	-

Soil Quality Assessment	VS-Fast Score
Poor	< 5
Moderate	5 – 10
Good	11 - 16

Other Notes, e.g. Site Photo; Soil Photo or Sketches of soil, pit location...



30
cm

Immediately adjoining field to the treeline in site 3 a, shows dramatic decline in organic matter and very poor structure from routine ploughing
NOTE: though “only” oxen-based single plough – still very strong potential for loss of organic matter and the formation of a plough pan.

Impact is very obvious here as the soil is inherently very weakly structured.

Strong visual differences between these two adjoining sites reflected in their VS-Fast scores:
treeline: 22 (the max value)
field: 3 (“poor condition”)