thinksoils

Introduction

introduction

The 'think soils' manual is a practical guide to soil assessment. It aims to help farmers, land managers, government and non-government advisers to recognise problems with erosion and runoff from agricultural land. Our changing climate makes this issue increasingly important.

Diagnosing the state of soils on the farm is often not simple. Every field is unique. Soil condition can vary considerably within the field and at different depths, and it can also vary through the year depending on land management. Taking the time to look at soil structure is fundamental to achieving better land management, which supports profitable farming and helps protect the environment.

This guide was developed with help from farmers, soil surveyors, Environment Agency staff and agriculture advisers. With their help we have tried to make the guide accessible, practical and relevant. It covers agricultural soils in England and Wales and considers how weather conditions, landscape, land use and soils can combine to increase the risk of erosion and runoff. Specific guidance is given on how to examine soil in the field. Good and poor soil structure is illustrated and described on a range of soils. The manual also includes an overview of general land management principles. For different soils, case studies illustrate the diagnosis of soil problems and provide remedial options. To supplement the manual we have provided a list of further information sources and contacts at the back of the guide.

The 'think soils' manual is intended to support a variety of training and advice initiatives. For more information about this and any other enquiries, please contact our National Customer Contact Centre on 08708 506 506.

Problems associated with erosion and runoff

Soil on roads

Soil can be deposited on roads where there is erosion and runoff from fields. Wind can also blow soil onto roads.

Soil sediment can be subsequently washed into drains and watercourses.

Flooding

Runoff from fields can flow into property. This type of localised flooding does not necessarily involve a watercourse.

Where excessive runoff enters nearby watercourses, these can become overwhelmed causing flooding downstream.

Water pollution

Field runoff can contain soil sediment, organic matter, nutrients and farm chemicals. These have the potential to pollute water.

Degradation of river habitats

Soil sediment can smother river gravel, affecting fish and aquatic life. Salmon and trout eggs are particularly vulnerable to suffocation from sediment deposited in river gravel.

Organic matter and nutrients associated with sediment can also cause excessive bacterial and fungal growth and nuisance algae.

thinksoils

Factors that influence erosion and runoff

Factors that influence erosion and runoff

Factors that influence erosion and runoff

Soil
- texture
- wetness
- structure
- soil surface roughness

Landscape
- steep slopes
- field size and valley features
- proximity of watercourses
- field tracks and roads

Weather
- rainfall intensity
- climate and soils

Land use
- risks associated with crops and livestock

soil texture

Soil texture

Soil texture refers to the relative proportion of clay, silt and sand.

The risk of runoff and erosion is affected by small differences in texture. This is because texture influences the degree of percolation of water through the soil, and also the stability of soil.

Soils containing large proportions of sand have relatively large pores through which water can drain freely. These soils are at less risk of producing runoff. As the proportion of clay increases, the size of the pore space decreases. This restricts movement of water through the soil and increases the risk of runoff.

Soils with low clay content are less cohesive and are inherently more unstable. These soils are at greater risk of erosion by water and wind.

soil wetness

Soil wetness

Naturally waterlogged soils are known as gley soils. Soils affected by a high water table are groundwater gley soils, and those that are waterlogged due to slow percolation of water are known as surface water gley soils. Wet soils have greater risk of runoff.

After the summer and in well structured soils, without deep fissures or cracks, rain wets the soil progressively from the surface. This creates a wetting front that moves down the soil profile. Compacted layers within the soil will affect this wetting front and it may cause areas of surface ponding across a field.

Grey and bluish-grey colours develop in saturated soils due to a lack of air and the reduction of iron compounds. A patchwork of bluish-grey colours occur together with orange, yellow or rusty colours (mottles) in the zone where there is waterlogging for part of the year. Orange / yellow colours occur where iron has re-oxidised.

soil structure

Soil structure

Soil structure refers to the arrangement of soil particles in the soil. Clay content, organic matter (and in some soils calcium and iron compounds) help to bind the soil together into structural units, aggregates or peds.

Well structured soil allows the free movement of air and water through fissures (or cracks) between the structural units. Pores within the units also allow the movement of air and water. A soil with poor soil structure has a high risk of generating runoff. The risk of runoff is greatest when poor soil structure is near the soil surface.

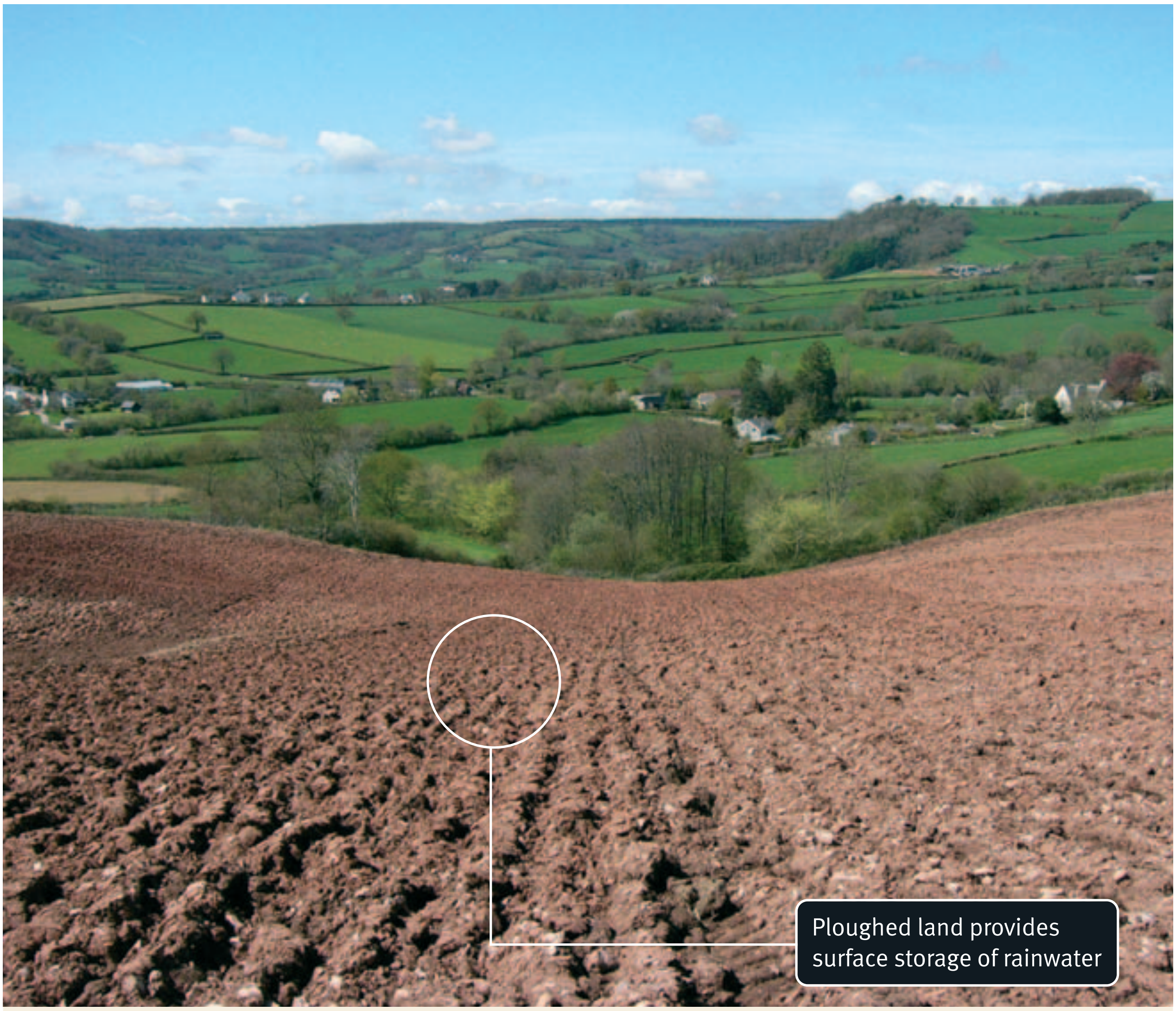
Soil structure deteriorates when structural units are deformed producing a dense single mass of soil (or large soil units). This occurs when pressure is applied to a wet and soft soil.

Pressure squeezes the soil units together and reduces pore space within the units. A dry soil can withstand pressure without deforming soil structure.

Some soils are unstable when clay, calcium or organic matter content is low. Unstable aggregates disperse when wet, forming a solid mass as the soil dries. Where this occurs at the immediate soil surface, the soil may form a cap or crust.

Soils can restructure due to natural fracturing processes when clay shrinks and swells, and by cultivation. Biological activity also restructures soil.

soil surface roughness



Soil surface roughness

Rough surfaces (e.g. in ploughed land, coarse seedbeds, or pressed land with indentations) help to slow down runoff. Roughness provides storage of rainwater, allowing water to collect before it soaks into the soil. For some fields, extra storage can be created if the ploughed land is worked across a slope and not up and down a slope i.e. the ridge and furrows now act as little dams and storage areas.

Rough surfaces also help to reduce wind speed at the immediate soil surface, preventing wind erosion.

generic soil groups

Generic soil groups

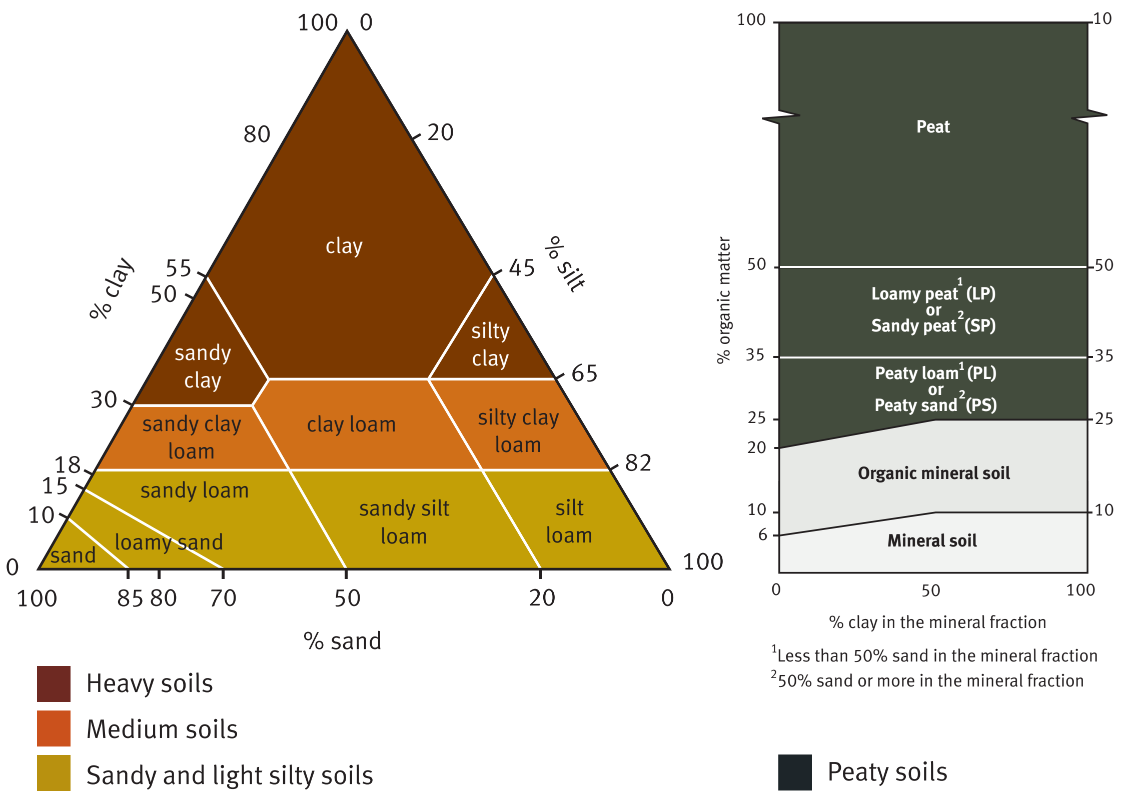
There are a number of methods for grouping soils according to their risk of erosion and runoff. The approach used in this document has been to group soils into 5 generic soil groups:

- sandy and light silty soils
- medium soils
- heavy soils
- chalk and limestone soils
- peaty soils

This approach enables soils to be grouped according to risks associated with:

- clay content (affecting porosity, risk of runoff, stability and erodibility),
- shallow soils on chalk and limestone (that are very stable, freely draining with low risk of runoff),
- peaty soils (with high risk of runoff and erosion in the uplands, and high risk of wind erosion in the lowlands).

Soil texture classification for mineral soils, and for soils with high organic matter



generic soil groups

Sandy and light silty soils

These soils have low clay content (<18%) in the topsoil, and include sand, loamy sand, sandy loam, sandy silt loam and silt loam textures.

Due to the low clay and organic matter content these soils have low aggregate stability. Soils readily disperse (slake) in water causing internal slumping and capping at the surface.

Where these soils are freely draining, and well structured, they have low risk of runoff.

However where the drainage is impeded by high water table or a slowly permeable subsoil, they are at high risk to structural damage and runoff.

Where runoff occurs these soils have a high risk of erosion.

Fine sandy soils have a high risk of wind erosion.

generic soil groups

Medium soils

Medium soils include sandy clay loam, clay loam and silty clay loam textures. They have a clay content between 19 and 35% in the topsoil. The higher clay content produces a greater aggregate stability than lighter soils. However, medium soils with a high content of silt or fine sand are not as stable, and are prone to capping, particularly where the organic matter content is low.

Clay content in the subsoil (and depth to the water table) affects the drainage of medium soils. Where clay content is low in the subsoil these soils can be freely draining with low risk to structural damage.

Conversely, where the clay content is high, they are prone to waterlogging and structural damage.

Structural damage, or poor drainage, in medium soils can lead to runoff and soil erosion, particularly in areas of high rainfall and on slopes.

generic soil groups

Heavy soils

These soils have a clay content >35% and include sandy clay, clay and silty clay textures. They are naturally slow draining and lie wet for long periods.

Some clay soils have a naturally well developed soil structure which lessens the incidence of waterlogging.

The stability of clay and porosity is dependent on the type of clay and the calcium content. Less stable acidic clays have lower porosity and higher risk of runoff than calcareous clays.

Heavy, slowly draining soils have a high risk of structural damage and generating runoff, but have a low risk of erosion.

generic soil groups

Shallow chalk and limestone soils

These thin soils are less than 30cm deep. They are highly calcareous, often with a medium textured topsoil. The soils have stable aggregates and form a strongly developed soil structure. Topsoil can be lost on these soils, exposing the bedrock, due to soil creeping down slopes.

The soils are naturally well drained and accept most winter rainfall with low risk of runoff.

generic soil groups

Peaty soils

This group includes peaty soils where the organic content of the topsoil is more than 20% organic matter (or 12% organic carbon). They include peaty sand, peaty loam, loamy sand, loamy peat and peat textures.

Peaty soils are widespread in the uplands and are also found in lowland bogs and river valleys. The Fens of eastern England and the Lancashire Mosses are very productive agricultural soils. These flat, artificially drained peaty soils have a low risk of runoff.

Peaty and organic soils that lie wet in the uplands have a small capacity to accept winter rainfall, with a consequent high risk of generating runoff and soil erosion.

In the lowlands and drier parts of the country, peaty soils are prone to wind erosion because of their low density and loose soil structure. When drained they are vulnerable to oxidation, causing peat 'wastage'.

weather

Rainfall intensity

Runoff occurs when rainfall intensity exceeds infiltration rate and the soil becomes saturated at the surface.

During winter, soils are often described as being at field capacity. This is the maximum water content held in the soil under free drainage. At field capacity, air is held in macropores and the soil can absorb rainfall until it becomes saturated.

Naturally well drained soils rarely become saturated and readily absorb most rainfall. Where the surface loses its porosity, runoff can occur on well drained soils when rainfall is as low as 1mm/hr.

weather

Climate and soils

Soil structure is at risk of being damaged when pressure is applied to a wet soil with a putty-like behaviour (i.e. in a moist plastic state). Trafficking, trampling and working of soils when they are too wet is a major cause of deterioration in soil structure.

Eastern England is much drier than the west and there is much greater opportunity for timely landwork without damaging soil structure.

The risk of wind erosion is greatest in the drier eastern areas of England.

landscape

Steep slopes

Steep fields can cause water to run off at a rapid rate. This is particularly the case where water percolation into the soil is slow (on naturally slowly draining soil or where there is poor soil structure, or both). Highest risk fields are those greater than 7^{o}.

Fields with gentle slopes less than 3^{o} are at lower risk to rapid runoff and erosion. But water can still run and gather momentum on gentle slopes, particularly where the slope is long and infiltration rate is slow.

Where the ground is level, water will tend to pond.

Field size and valley features

Large fields with long slopes can accumulate large volumes of water. Valley floors can concentrate water flow causing channel erosion. Wheelings and cultivation marks can also influence the direction of water movement.

Wind erosion tends to occur on unsheltered land exposed to strong winds, and in areas where wind is funnelled.

Proximity of watercourses

Fields adjacent to watercourses are at higher risk of causing water pollution associated with runoff than those where there is no connectivity to watercourses.

Field tracks and roads

Field tracks and roads provide a route-way for runoff, soil sediment and associated pollutants to enter watercourses. Roads and field tracks can link fields with watercourses that are kilometres apart.

Runoff from roads and adjacent land can also wash onto fields causing field runoff and erosion.

land use / cereals

Late sowing in the autumn

Winter cereals sown during late October and November can put the land at risk of runoff and erosion on sandy and light silty soils due to lack of crop cover over the winter and because of the high risk of the soil surface becoming capped.

Fine smooth seedbeds

Land with a fine and smooth seedbed provides little surface storage capacity, and on sandy and light silty soil is at risk of becoming capped causing runoff and erosion.

Fine, dry sandy tilths are vulnerable to wind erosion.

land use / cereals

Compacted seedbeds

Land under winter cereals is at risk to generating runoff where the soil is compacted (e.g. when sowing is carried out on wet soil, or where soil has become compacted during previous land work in the rotation).

Crops established by shallow cultivation are at risk of runoff if there is poor soil structure near the soil surface.

Compacted cereal stubble

Where cereals are harvested in wet conditions, there is a risk of causing soil compaction and runoff.

Compacted tramlines and wheelings are at most risk of runoff, especially when aligned up and down a slope.

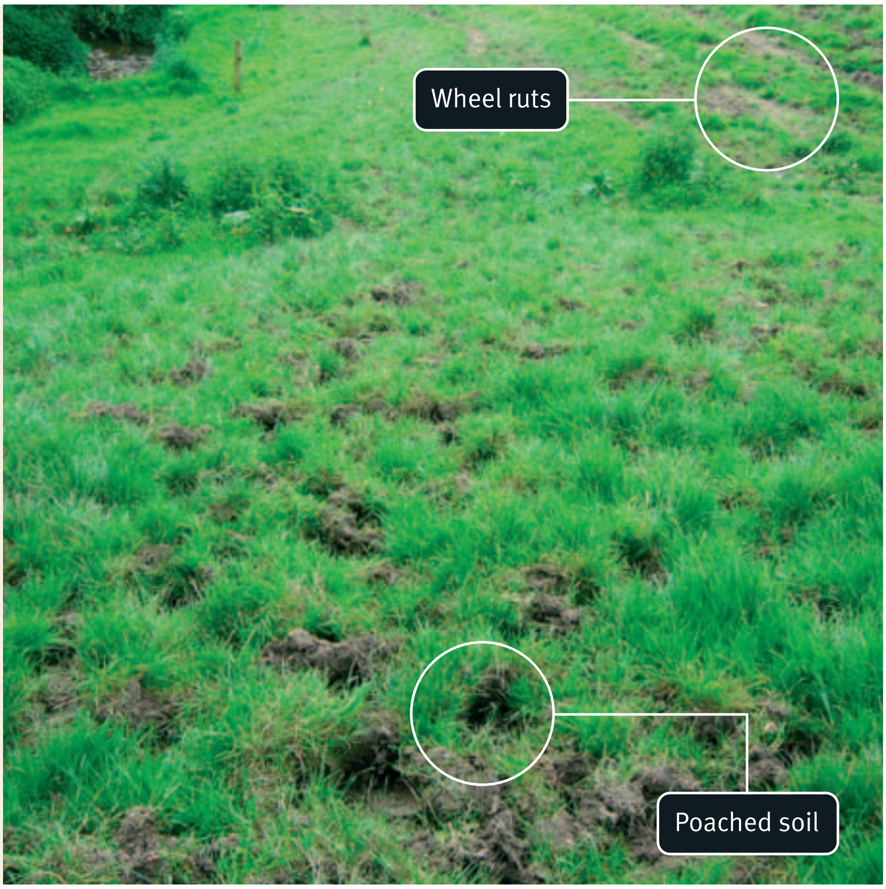
land use / livestock

Grassland management

Grassland is at risk to poaching and compaction due to grazing when the soil is too wet. Risks are particularly high during autumn and spring.

Farm vehicles can also cause compaction (e.g. transporting heavy trailer loads of silage in wet spring conditions).

Soils can restructure in grassland due to high earthworm activity, the dense network of roots, and drying of the soil causing shrinkage and fissuring of clay.



Out-wintering of stock

Out-wintering of stock has a high risk of causing soil compaction and runoff. Soils are trampled, particularly in areas around ring feeders. Trafficking to feed stock can also cause soil compaction.

Cultivation is often necessary to improve soil structure in badly damaged fields following out-wintering of stock.

land use / livestock

Wheel ruts caused during harvesting of maize

Harvesting forage crops

Maize and other forage crops are often harvested when soils are wet and vulnerable to compaction during autumn (and winter). Compacted maize stubble is a common cause of field runoff during winter.

These crops are also at risk to runoff during heavy rainfall in early summer when there is a lack of crop cover and the soil becomes capped (or due to runoff along compacted tramlines).

Slurry spreading on wet soil is at high risk of being washed off

Spreading slurry and manure during winter

Soil structure is at risk of being damaged when slurry and heavy loads of manure are spread in the winter onto wet soft soils.

Where soils are compacted slurry can run off the soil surface during rainfall.

land use / root crops and vegetables

Runoff from potatoes grown on long steep slopes

Spring land work

Growing root crops and vegetables often involves deep cultivation, stone removal and clod separation, bed forming, and use of plastic or fleece. These operations are carried out in spring when subsoils can still be too wet and vulnerable to compaction by heavy machinery.

In steep fields, rows and beds are formed up and down the slope because harvesting equipment can not operate across the slope. Rows and beds channel water downhill increasing the risk of rapid water runoff.

Fine tilths (e.g. for carrots, onions and sugar beet) on sandy and peaty soils are also vulnerable to wind erosion

land use / root crops and vegetables

Compacted headlands and wheelings causing runoff and soil erosion

Headlands, tramlines and tracks

Potatoes and vegetables involve many vehicle movements to spray crops and for irrigation.

Headlands, tramlines and tracks are most at risk of becoming compacted and causing runoff.

Lifting and transporting heavy loads of potatoes causing soil compaction

Autumn harvesting

Where root crops and vegetables are harvested in autumn and winter (when soils are wet and soft) there is a high risk of causing compaction and runoff.

Transporting heavy loads of root crops is a major hazard to the soil in wet conditions where wheel ruts result in deep compaction and subsequent channelling of runoff.

thinksoils

Examining soils in the field

examining soils in the field

the soil surface

the soil surface

Looking for rill erosion

Erosion is a severe form of soil degradation where topsoil is removed by running water carving out channels.

Small channels are known as rills. These can be removed by ploughing.

Rill erosion of soils in a winter cereal crop

Looking for gulley erosion

Deep gulley erosion occurs where large volumes of surface water collect at the base of slopes and in valley bottoms. This is a severe form of erosion that can not be removed by ploughing.

Gulley erosion in the bottom of a valley

the soil surface

Looking for signs of soil deposition caused by erosion

When soil is eroded, the coarse heavier fraction of soil may be deposited at the bottom of the slope.

The finer material and organic matter is often carried further away from the field into watercourses.

Picture: John Allen

Looking for signs of wind erosion

Some sandy soils and peaty soils are at risk of wind erosion.

Sandy soils at risk to wind erosion are those with a low clay content (including sand and loamy sand textures), and those with fine soil particles. Sandy loam soils are slightly more stable and have a lower risk of being blown.

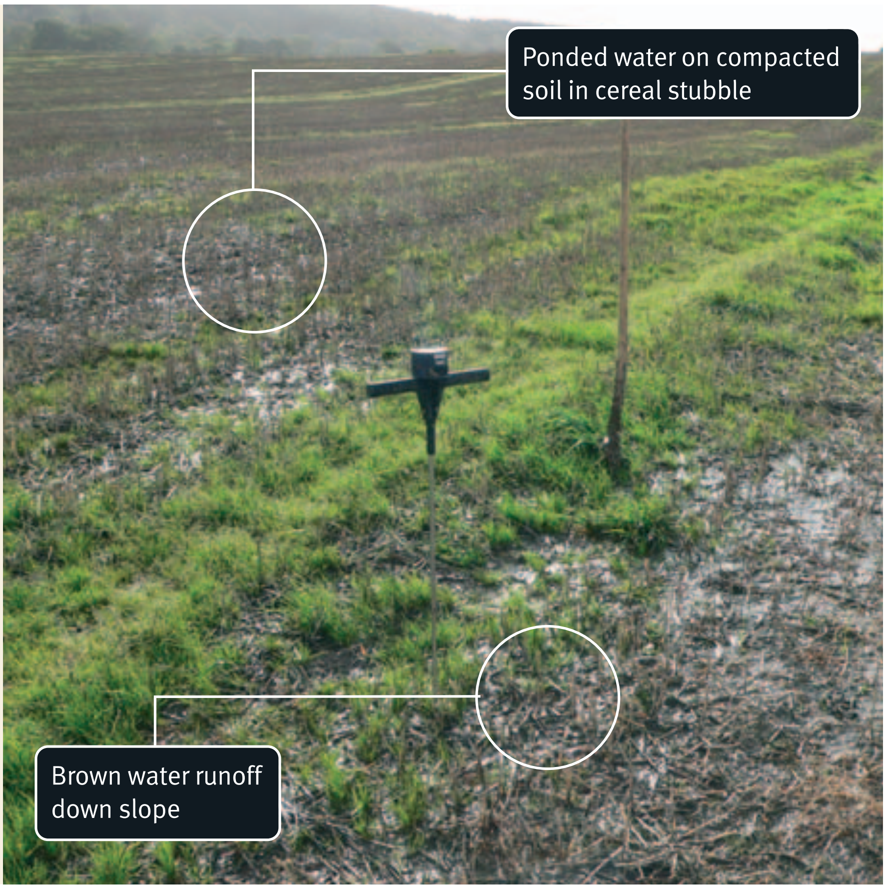
Signs of wind erosion include drifting soil, buried seedlings, and soil blown into hedgerows, ditches and onto nearby roads.

the soil surface

Looking for signs of runoff and compaction

Examining soils during or just after rainfall is a good time to see signs of compacted soil. Where water cannot infiltrate into the soil it ponds at the surface. Where this occurs on slopes, water flows downhill but does not necessarily cause rill or gulley erosion.

Excessive water flow and slight soil erosion can cause turbid or brown water runoff (often termed soil wash).

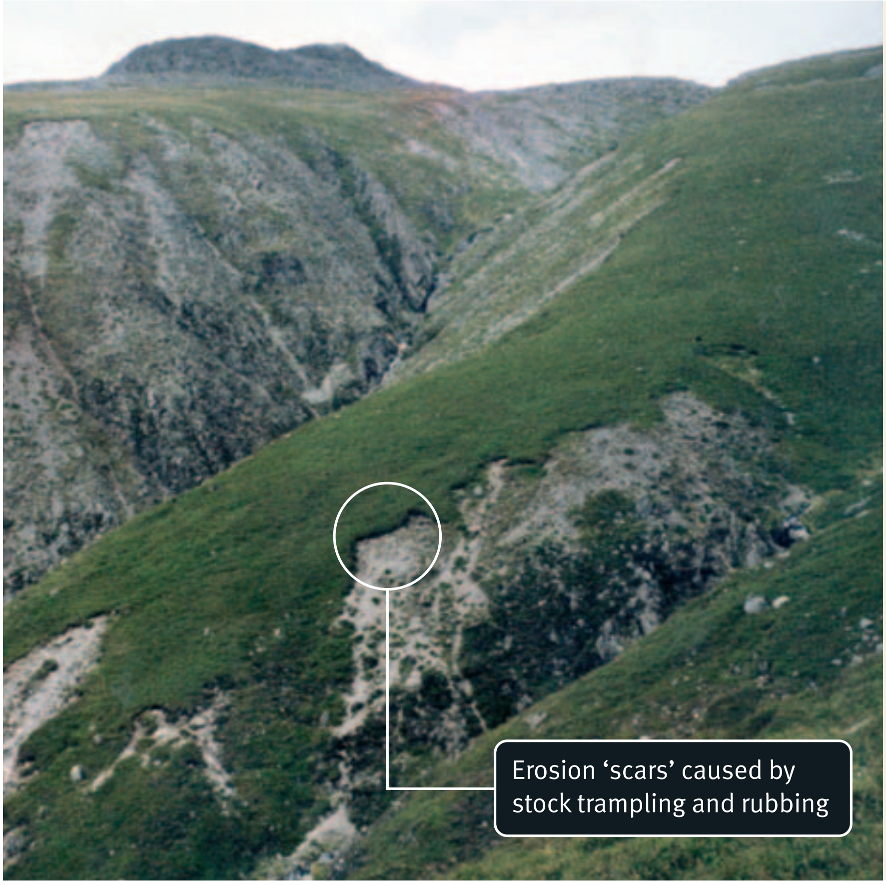


Looking for wheel ruts

Wheel ruts are caused by farm traffic travelling on wet soil. This causes compaction and reduces the ability of the soil to absorb rain.

Wheel ruts can channel water (for example towards the farm gate and the adjacent road).

the soil surface



Looking for signs of soil erosion in the uplands

Treading of soil by stock in upland areas can lead to soil erosion.

Crescent shape erosion features (known as scars) are caused by stock trampling, rubbing and scratching. These scars can join together forming a large area of exposed soil that is vulnerable to erosion.

Looking for a poached soil surface

Poached soil is caused when livestock trample wet soil. Poaching causes compaction and ponding of water.

Although the hoof marks provide some surface storage of water, runoff can occur during heavy rainfall.

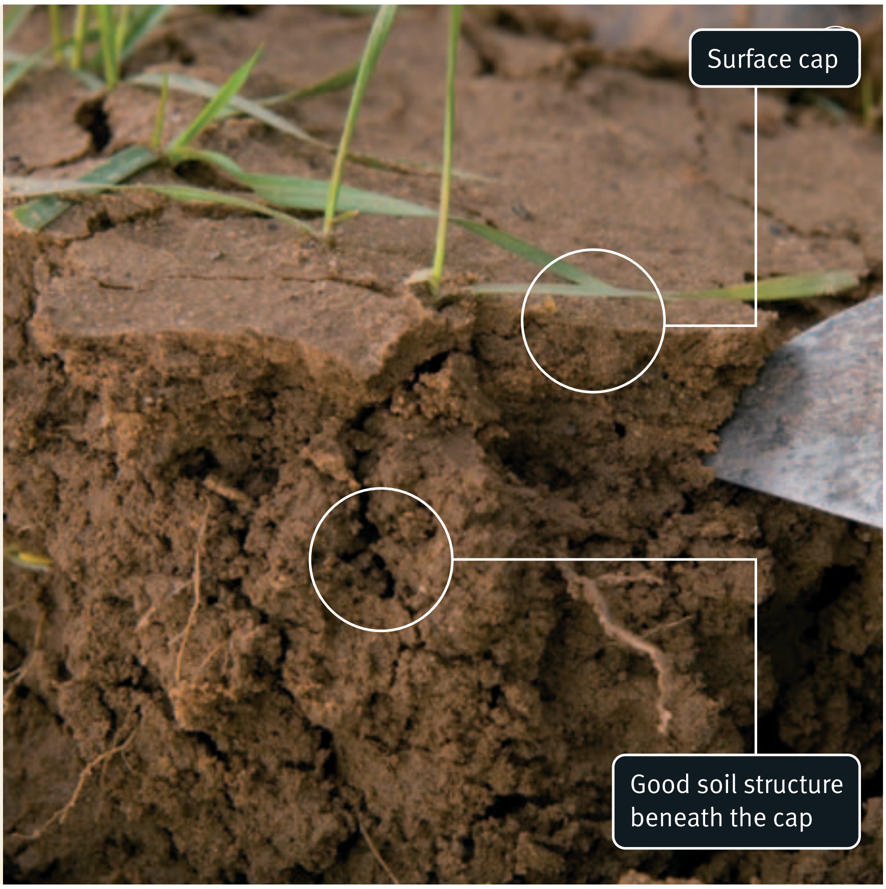
the soil surface

Looking for a surface cap

Slaking is the process of breaking down soil aggregates. Rain impact breaks down soil fragments which are then dispersed in solution and fine particles are washed into pores, forming a crust or cap.

Capped soils reduce the ability of rain to soak into the soil, causing runoff.

A cap can be identified by gently prising the soil open with a spade.



Good surface condition

A good surface condition is where soil aggregates have not disintegrated either by the action of rain or by compression from farm machinery or livestock.

examining soils in the field

the topsoil

the topsoil

Preparing a hole for examination

Normally at least three holes need to be dug in a field to obtain a representative picture. More holes will be needed in large fields and where there are a range of soil types. Areas prone to compaction and possible sources of runoff should be examined (for example, headlands and wet spots), and areas where crop growth is poor should also be looked at.

Mark out the edges of a square hole to be dug. Each edge needs to be about 50cm so that a sufficiently deep hole can be dug. (Depth of the overall hole would normally be at least to 40cm.)

Preparing a section of topsoil to be examined

Dig out soil from one half of the square to a depth of about 20cm within the cultivated layer. The remaining soil is the section of topsoil to be examined, so do not trample on this half and do not smear the face with the spade.

the topsoil

Looking at pores and fissures

Lever out a spadeful of soil from the undisturbed half of the square so that soil structure can be examined.

The first step when examining soil structure in a spadeful of soil is to look for spaces (either fissures between soil structural units, or pores within the units).

Soil with good structure has abundant pores and fissures allowing good drainage, aeration, root growth and biological activity.

Soil with poor structure is where there are few pores and fissures, or where there are horizontal fissures.

the topsoil

Peds are naturally formed structural units that separate cleanly from one another when gently teased apart

Looking at structural units

The second step to examining soil structure is to look at the soil structural units. This is most easily done when the soil is moist.

Carefully tease the soil apart along its lines of natural weakness, breaking the soil into structural units.

A structureless soil is without any aggregation of soil particles. It is massive when soil particles are bonded together into one single mass, or single grain when soil breaks to individual soil particles.

A soil has structure when soil is aggregated into units. Structural units that are naturally formed are called peds. These are formed by shrinking and swelling of clay, producing angular shapes, or by biological processes that produce more rounded faces. Calcium also helps to bind clay particles together.

Cultivation produces artificial aggregates and these are less permanent than peds and often do not persist through cycles of wetting and drying. These aggregates are termed clods (or fragments if they are less than 10cm).

A strongly developed ped structure is where peds are clearly evident, separating cleanly from one another when the soil is disturbed. Conversely a weakly developed ped structure is where peds are less obvious and there is much unaggregated material.

the topsoil


Granular soil structure


Very coarse subangular blocks


Medium and coarse angular blocks with rusty mottles


Platy soil structure

Looking at shape, size and colour of soil structural units

Spherical structures are termed granular. Square shapes are called blocks. Flattened structural units are called plates.

Where blocks have mainly curved /rounded faces they are termed subangular. Where faces are mostly flat the blocks are termed angular.

Small blocks are called very fine when they are ‹5mm, fine when they 5-10mm and medium when they are 10-20mm. Large blocks are called coarse when they are 20-50mm and very coarse when they are ›50mm.

Soils with coarse and very coarse angular blocks, and those with plates, have poor drainage and aeration because blocks and plates can fit tightly together. Conversely, fine granules and fine subangular blocks allow good drainage and aeration.

Soil colour is a good indicator of the degree of waterlogging. When soil is poorly drained it has less oxygen, and iron is reduced, producing a grey colour. Conversely, a well-oxygenated soil is brown in colour. Repeated cycles of oxygenation and reduction produce grey and rusty mottled colours.

the topsoil

Assessing the packing density of soil

Porosity of soil is affected by the packing density of soil particles. Soils with high packing density have lower porosity.

Packing density can be estimated by assessing the strength of soil and comparing this with size, shape and degree of development of peds.

Soil strength is determined by applying pressure to a 3cm cube of soil using an extended forefinger and thumb. The cube can either be a ped or part of a ped, or a block fashioned from massive soil. The cube should be orientated according to how the soil is found in the profile.

Where a moist cube cracks under gentle force it is described as friable. A soil is generally at least risk from compaction when in a friable state. Where a moist cube fails under the maximum pressure that can be applied by extended thumb and forefinger it is described as very firm.

Where a moist cube fails under pressure that is much less than the maximum that can be applied, it is described as firm.

A friable soil has a lower packing density and is more porous than a firm and very firm soil of the same texture.

examining soils in the field

the subsoil

the subsoil

Preparing a hole for examination

Subsoils should be examined when the soil is moist.

Dig out half of the soil in the pit to a 30-40cm depth. Take care not to smear the face or trample the soil in the remaining half of soil to be examined.

Preparing a section of subsoil to be examined

Dig into the remaining half of soil and cut out a block of soil.

Lever out a block of soil with the spade and hold the soil with the hand to stop it falling and carefully remove from the hole.

the subsoil

Looking at pores and fissures

Subsoils with natural soil structure tend to have larger peds than structural units in the topsoil. This is because the natural processes that form peds (such as swelling and shrinkage of clay during wetting and drying cycles) are not as frequent in the subsoil. There is also less biological activity, root growth and organic matter in the subsoil.

Subsoils can have continuous pores created by earthworm channels.

Abundant fissues and pores allow for good rooting and water movement (where the water-table allows).

When examining the subsoil it is important not to confuse a change in soil texture with structural degradation. There is often a boundary between the tilled and untilled soil, and this change should not be mistaken for degraded soil structure.

the subsoil

A strongly developed subsoil structure

Looking at structural units

Carefully tease apart the subsoil, breaking it along its natural lines of weakness. Assess the degree of ped development, and the size, shape and colour of peds.

A structureless subsoil can either be natural, for example where the clay content is low and the soil has naturally slaked (slumped), or it can be formed by compression of moist soil by farm traffic and cultivation.

A strongly developed ped structure is where the peds are clearly evident and easily break apart into well-defined units.

the subsoil

Structureless massive subsoil

Very coarse plates

Medium prism with rusty mottles

Coarse subangular blocks

Looking at shape, size and colour of soil structural units

Subangular blocks, angular blocks and prisms tend to be found in subsoils.

Prisms are where the peds have long vertical faces. Prism size range from very fine (<10mm width), through to fine (10-20mm width), medium (20-50mm width), coarse (50-100mm width) and very coarse (>100mm width).

Root and water movement is more likely to be restricted where the peds are coarse (large) and where they are angular, prismatic or platy.

Subsoils that are mottled indicate poor drainage, and a high risk to structural damage.

the subsoil

Assessing the packing density of subsoil

Packing density can be estimated by assessing the strength of subsoil and comparing with size, shape and degree of ped development. Apply pressure to a 3cm cube of soil using an extended forefinger and thumb. The cube can either be a ped or part of a ped, or a block fashioned from massive soil. The cube should be orientated according to how the soil is found in the profile.

Where a moist cube fails (cracks) under gentle force it is described as friable. Where a moist cube fails under the maximum pressure that can be applied by extended thumb and forefinger it is decribed as very firm. Where a moist cube fails under force that is much less than the maximum it is described as firm.

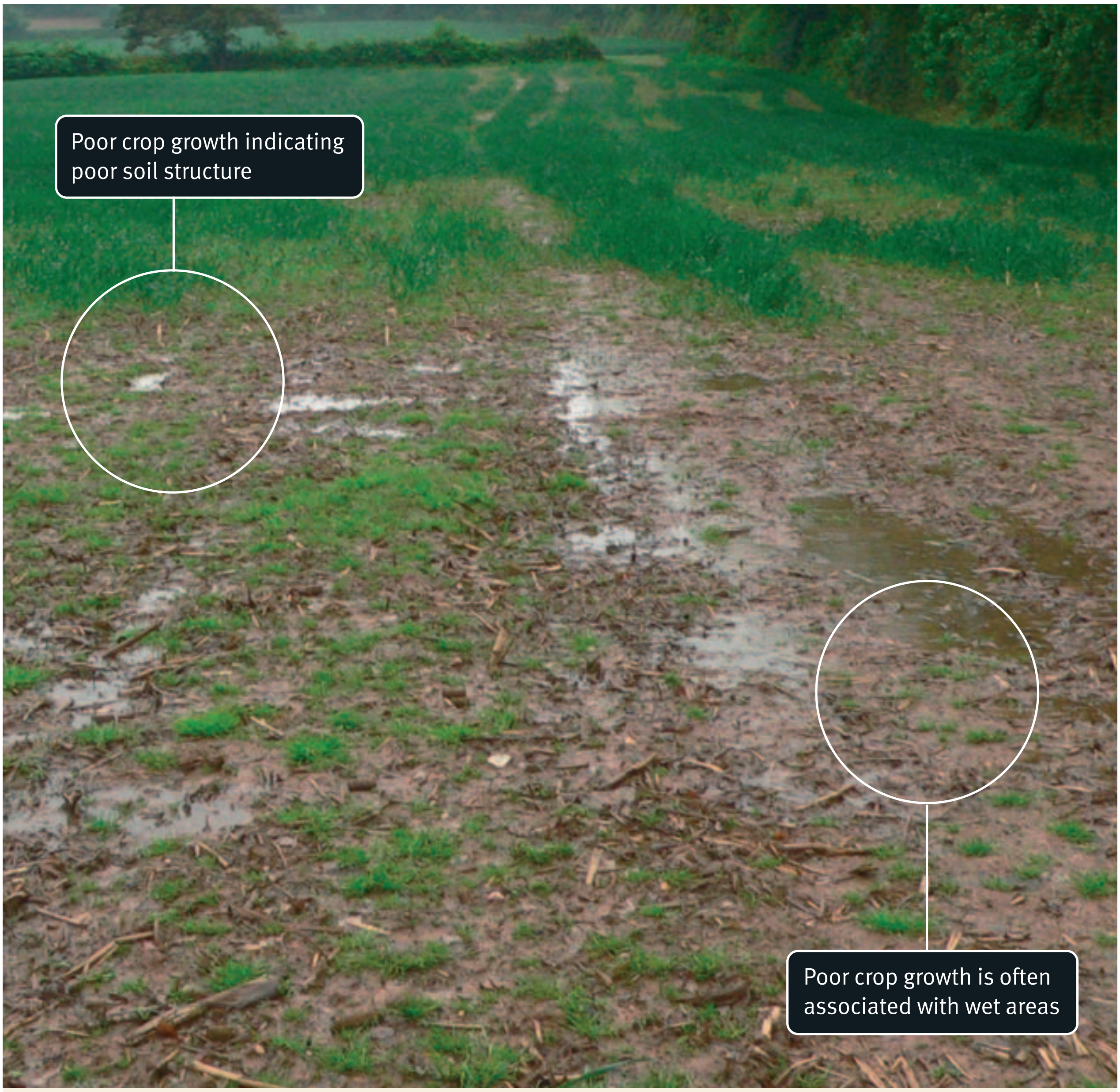
A friable soil has a lower packing density than a firm and very firm soil of the same texture. Soils with low packing density are more porous than soils with high packing density.

Sandy and light silty soils with a friable soil strength are moderately or very porous even though they may be structureless.

examining soils in the field

plants and plant roots

plant growth



Using plant growth as an indictor of poor soil structure

Crop and grass growth can be affected by poor soil structure.

Plant growth is most at risk on headlands, near gateways, and wet areas in the field (where soil is prone to structural damage by vehicles or stock). These areas are also potential sources of runoff and erosion.

Wet areas in the field can either be natural, for example where the water table is high, or they can be caused by poor soil structure.

Soil structure is often degraded in wet areas, which further compounds problems of waterlogging and poor crop growth.

root growth

Looking at root growth as an indicator of soil structure

Roots are very sensitive to soil structural condition, wetness and aeration. They can extend 2m deep in the soil, and autumn sown crops often have roots deeper than 1m by the following spring.

The soil should be examined to determine root abundance, root depth, direction of growth, and whether roots have penetrated structural units, or are confined to fissures.

Roots will take the path of least resistance and hence are good indicators of soil structural conditions and porosity. Ideally, they will grow vertically through fissures or cracks and pores present in a well structured soil. On encountering zones of compaction they are likely to be impeded vertically and so will grow horizontally. This will limit the depth and hence volume of soil from which the roots can extract water and nutrients for the growing crop.

Roots can grow in poorly structured soil provided there are pores for the roots to grow through (e.g. worm holes). In some soils, roots can not penetrate into dense structural units, and are confined to fissures where they may find moisture and nutrients.

thinksoils

Identifying soil structural problems in the field