

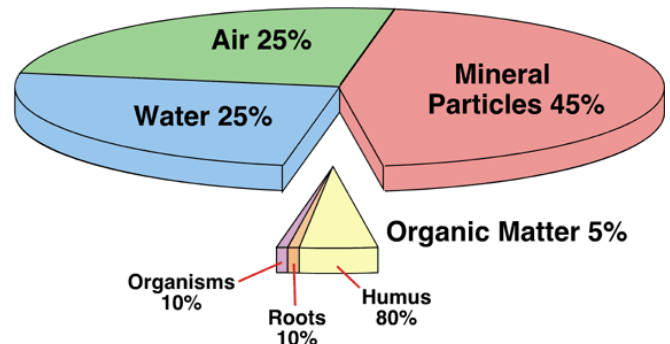
Soil

The Basics

Soil is the uppermost surface of the earth, which has been slowly transformed by decomposition due to the effects of weather, vegetation and human activities. The parent material from which soil is formed can be the underlying rock, deposits from rivers and seas (alluvial soils) or the wind (aeolian soils), or volcanic ash.

Soils is composed of:

- * mineral particles
- * air
- * water
- * organic matter



Soil texture and structure are of special importance for soil fertility and plant growth:

- * Solid particles are classified by size into gravel and stones, sand, silt and clay.
- * Soil texture refers to the relative proportions of sand, silt and clay in the soil. Depending on the soil's texture, it is described as sand, sandy loam, loam, clay loam, clay, etc. Soil can also be characterized as light, medium or heavy based on its workability.
- * Soil structure refers to the aggregation of the finer soil particles into crumbs or larger sizes.

Soil supports plants by providing a permeable layer for their roots. It stores plant nutrients and water. Depending on their composition, soils differ in their ability to supply plant nutrients.

Factors determining soil fertility

The main factors that determine soil fertility are:

- * soil organic matter (including microbial biomass)
- * soil texture / structure
- * soil depth
- * nutrient content
- * water holding capacity
- * drainage
- * soil pH
- * absence of toxic elements

Contrary to what is widely believed, the colour of the soil reveals very little about its fertility.

How does soil hold nutrients and release them?

Decomposing rock material forms soils and releases plant nutrients. The original mineral content of this material - and the nature and intensity of the decomposition process - determine the kind and amount of nutrients released. Clay and organic matter retain nutrients in a plant-available form, that is, the nutrients are attached to the soil constituents.

Soil's ability to retain a certain amount of nutrients determines its natural fertility.

Nutrients, which carry positive and negative charges (cations and anions), are attracted by the clay and organic matter in the same way that metal filings are attracted by a magnet.

Soil water containing the nutrients in dissolved plant-available form is called the soil solution. Nutrients can only be taken up by roots in dissolved form. Therefore, they have to be released from the storing complex into the soil solution to be plant-available.

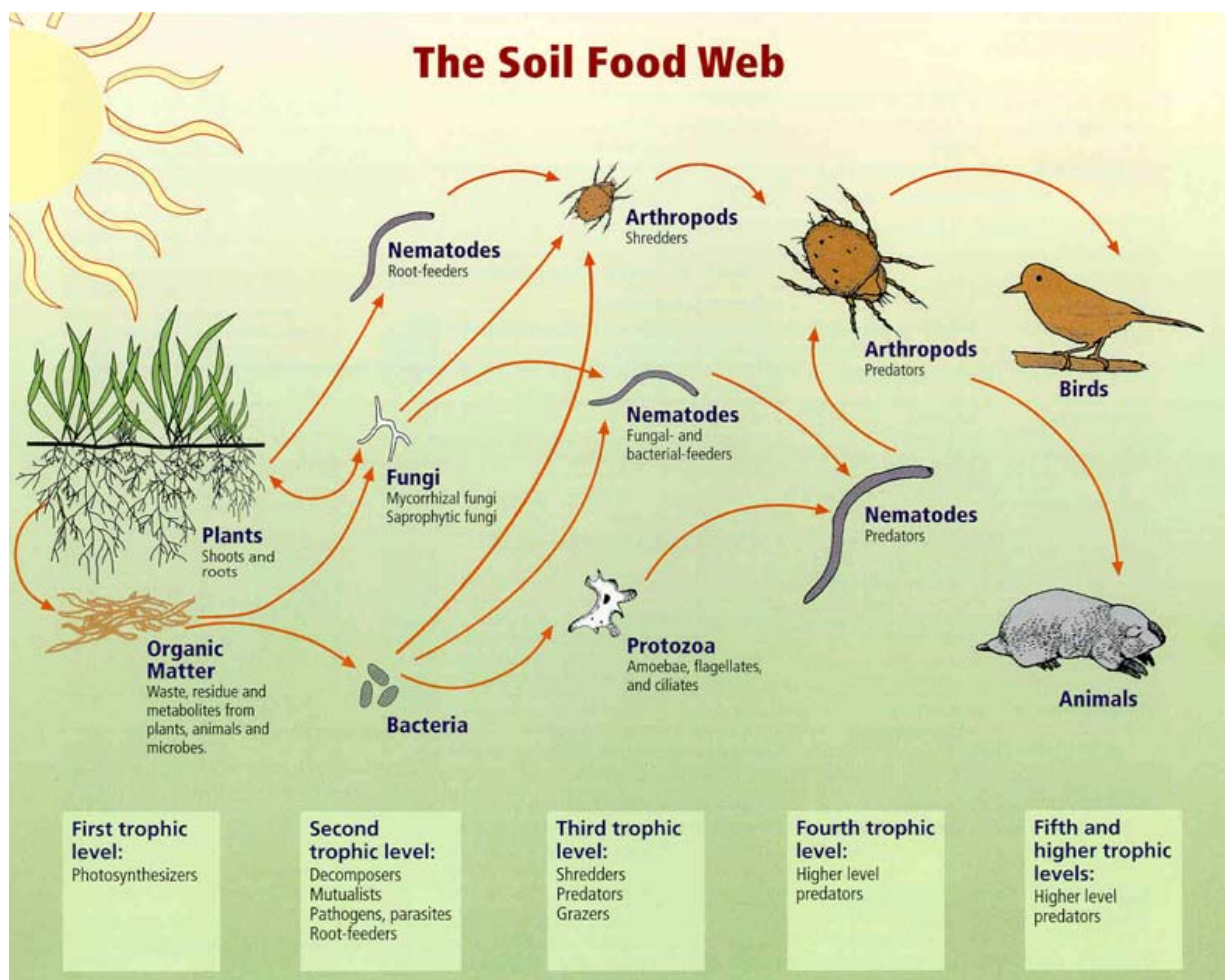
Organic matter can absorb more nutrients than a comparable amount of clay. It is therefore important to build up the organic matter, especially in degraded tropical soils with less ability to absorb the mineral component.

Soil organisms increase soil fertility

The activities of soil organisms are indispensable for high soil fertility and good crop production. Most of these activities are beneficial for the farmer. Soil organisms decompose organic matter to produce humus; aggregate soil particles to provide better structure; protect roots from diseases and parasites; retain nitrogen and other nutrients; produce hormones that help plants grow; and can convert pollutants that find their way into the soil.

The Soil food web

Soil organisms form the basis of a complex food web, of which we are a part. The species that form these webs are of course very specific to each environment. Bacteria and fungi, the bottom of the food chain are ultimately eaten by us all and critical to a healthy system. They feed on decomposing organic matter and a small amount can make a big difference to soil fertility.

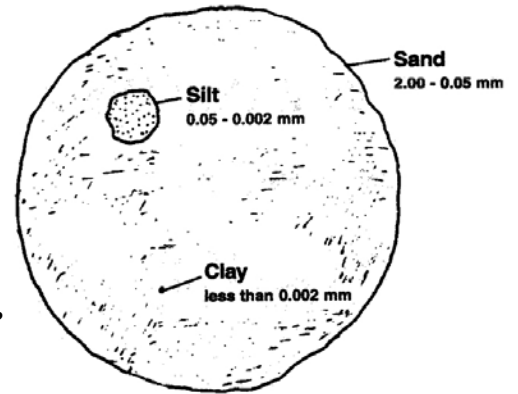


Source: USDA Natural Resources Conservation Service

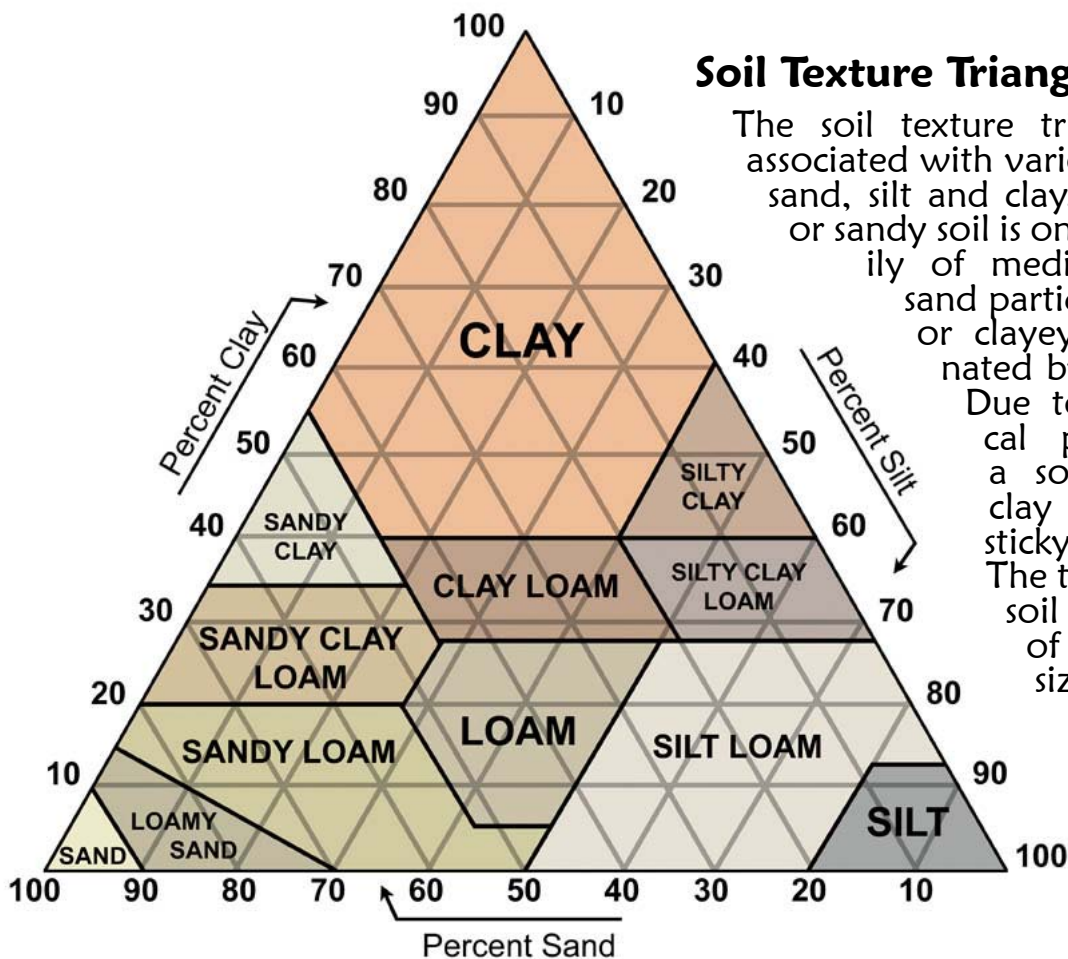
Estimating Soil Texture

Sand, Silt and Clay

Texture refers to the size of the particles that make up the soil. The terms sand, silt, and clay refer to relative sizes of the soil particles. Sand, being the larger size of particles, feels gritty. Clay, being the smaller size of particles, feels sticky. It takes 12,000 clay particles lined up to measure one inch. Silt, being moderate in size, has a smooth or floury texture.



Particle name	Particle diameter
Very coarse sand	2.0 to 1.0 millimeters
Coarse sand	1.0 to 0.5 millimeters
Medium sand	0.5 to .25 millimeters
Fine sand	0.25 to 0.10 millimeters
Very fine sand	0.10 to 0.05 millimeters
Silt	0.05 to 0.002 millimeters
Clay	below 0.002 millimeters



Soil Texture Triangle

The soil texture triangle gives names associated with various combinations of sand, silt and clay. A coarse-textured or sandy soil is one comprised primarily of medium to coarse size sand particles. A fine-textured or clayey soil is one dominated by tiny clay particles. Due to the strong physical properties of clay, a soil with only 20% clay particles behaves as sticky, gummy clayey soil. The term loam refers to a soil with a combination of sand, silt, and clay sized particles. For example, a soil with 30% clay, 50% sand, and 20% silt is called a sandy clay loam.

Identifying Texture by Feel

Feel test – Rub some moist soil between fingers

- * Sand feels gritty
- * Silt feels smooth
- * Clays feel sticky

Ball squeeze test – Squeeze a moistened ball of soil in the hand

- * Coarse textures (sand or sandy loam) soils break with slight pressure
- * Sandy loams and silt loams stay together but change shape easily
- * Fine textured (clayey or clayey loam) soils resist breaking

Ribbon test – Squeeze a moistened ball of soil out between thumb and fingers

- * Sandy or sandy soils won't ribbon
- * Loam, silt, silty clay loam or clay loam soil ribbons less than 1 inch
- * Sandy clay loam, silty clay loam or clay loam ribbons 1 to 2 inches
- * Sandy clay, silty clay, or clay soil ribbons more than 2 inches

Note: A soil with as little as 20% clay may behave as a heavy clayey soil. A soil needs 45% to over 60% sand to behave as a sandy soil.

Identifying Soil Texture by Measurement (Jar Test)

- 1 Spread soil on a newspaper to dry. Remove all rocks, trash, roots, etc. Crush lumps and clods.
- 2 Finely pulverize the soil.
- 3 Fill a tall, slender jar (like a quart jar) $\frac{1}{4}$ full of soil.
- 4 Add water until the jar is $\frac{3}{4}$ full.
- 5 Add a teaspoon of powdered, non-foaming dishwasher detergent.
- 6 Put on a tight fitting lid and shake hard for 10 to 15 minutes. This shaking breaks apart the soil aggregates and separates the soil into individual mineral particles.
- 7 Set the jar where it will not be disturbed for 2-3 days.
- 8 Soil particles will settle out according to size. After 1 minute, mark on the jar the depth of the sand.
- 9 After 2 hours, mark on the jar the depth of the silt
- 10 When the water clears mark on the jar the clay level. This typically takes 1 to 3 days, but with some soils it may take weeks.
- 11 Measure the thickness of the sand, silt, and clay layers.
 - a. Thickness of sand deposit _____
 - b. Thickness of silt deposit _____
 - c. Thickness of clay deposit _____
 - d. Thickness of total deposit _____
- 12 Calculate the percentage of sand, silt, and clay.
- 13 Turn to the soil texture triangle and look up the soil texture class.



Source: Colorado State University website

Indicator Plants

SOIL INDICATORS

Common Name	Botanical Name	Dry	Wet	Cultivated/Tilled	Uncultivated/Neglected	Low N	High N	Low K	High K	Low P	High P	Sand	Clay	Hardpan/Crusty	Acid	Alkaline	Low Fertility	High Fertility	Salty
Agrimony		X																	
Artemisia maritima	<i>Artemisia maritima</i>																		X
Aster, sea																			X
Aster, swamp			X																
Bellflower	<i>Campanula sp.</i>															X			
Bindweed, field	<i>Convolvulus arvensis</i>											X		X					
Bindweed, hedge	<i>Convolvulus sepium</i>		X																
Bracken, eastern	<i>Pteridium aquifolium</i>							X		X					X				
Buttercups	<i>Ranunculus acris</i>		X	X									X						
Buttercup, creeping	<i>Ranunculus repens</i>		X										X						
Campion	<i>Lychnis alba</i>															X			
Carpetweed	<i>Mollugo verticillata</i>			X															
Carrot, wild	<i>Daucus carota</i>				X							X				X	X		
Catchfly, night-flowering	<i>Silene noctiflora</i>	X																	
Cattail	<i>Typha latifolia</i>		X																
Celandine				X															
Chamomile, corn	<i>Anthemis arvensis</i>		X					X						X		X			
Chamomile, German	<i>Chamomilla pecutita</i>													X	X				
Chickweed	<i>Stellaria media</i>			X														X	
Chicory	<i>Cichorium intybus</i>			X									X					X	
Cinquefoil, silvery	<i>Potentilla argentea</i>	X													X				
Clovers	<i>Trifolium sp.</i>				X														
Clover, hop	<i>Medicago lupulina</i>															X			
Clover, rabbit foot		X									X				X				
Clover, red	<i>Trifolium pratense</i>								X										
Clover, white	<i>Trifolium repens</i>	X		X															
Cockle, white	<i>Lychnis alba</i>											X							
Coltsfoot			X										X		X				
Cornflower	<i>Centaurea cyanus</i>											X							
Corn marigold												X			X				
Cotton grasses	<i>Eriophorum sp</i>		X																
Cudweed, low	<i>Gnaphalium sp.</i>		X																
Daisy, English	<i>Bellis perennis</i>												X		X				
Daisy, ox eye	<i>Chrysanthemum leucanthemum</i>		X	X															
Dandelion	<i>Taraxacum vulgare</i>			X									X		X				
Docks	<i>Rumex sp.</i>		X												X				
Dock, broad leaved	<i>Rumex obtusifolias</i>		X										X						
Fat hen	<i>Atriplex hastata</i>																	X	
Fingerleaf															X				
Foxtail, short awned	<i>Hordeum jubatum</i>		X																
Fumitory	<i>Fumaria officinalis</i>								X										
Goldenrods	<i>Solidago sp.</i>		X									X							
Goosefoot, oak leaved				X															
Grass, quack	<i>Agropyron repens</i>													X					
Groundsel	<i>Senecio vulgaris</i>			X														X	
Hawkweeds	<i>Hieracium sp.</i>														X				
Hedge-nettle, marsh			X																
Hellebore, false	<i>Veratrum californicum</i>		X																
Hemlock, poison	<i>Conium maculatum</i>		X																

continued

Source: Robert Kourik ~ 'Designing & Maintaining your Edible Landscape Naturally'

SOIL INDICATORS

Common Name	Botanical Name	Dry	Wet	Cultivated/Tilled	Uncultivated/Neglected	Low N	High N	Low K	High K	Low P	High P	Sand	Clay	Hardpan/Crusty	Acid	Alkaline	Low Fertility	High Fertility	Salty
Henbane, black	<i>Hyscymus niger</i>															X			
Henbit	<i>Camium amplexicaule</i>			X													X		
Horehound	<i>Marrubium vulgare</i>			X															
Horsenettle	<i>Solanum carolinense</i>			X		X						X							
Horsetails	<i>Equisetum sp.</i>		X										X	X					
Horsetail, field	<i>Equisetum arvense</i>		X									X							
Horsetail, marsh			X																
Joe-pye weed			X																
Knapweeds	<i>Centaurea nigra</i>							X							X				
Knawel	<i>Scleranthus annuus</i>														X				
Knotweed, prostrate	<i>Polygonum aviculare</i>			X											X				
Lady's thumb	<i>Polygonum periscaria</i>		X												X				
Lamb's quarters	<i>Chenopodium album</i>			X														X	
Lettuce, prickly	<i>Lactuca scariola</i>			X															
Lupine	<i>Lupinus sp.</i>					X													
Mallow, musk	<i>Malva moschata</i>			X															
Mare's tail	<i>Erigeron canadensis</i>		X																
Mayweed	<i>Anthemis cotula</i>												X	X					
Meadow sweet	<i>Astilbe sp.</i>		X																
Medic, black	<i>Medicago lupulina</i>					X													
Milkweed	<i>Asclepius syriaca</i>												X						
Mosses	<i>Bryophyta sp.</i>		X																
Mugwort	<i>Artemesia vulgaris</i>				X														
Mullein, common	<i>Verbascum sp.</i>				X										X		X		
Mustards	<i>Brassica sp.</i>													X	X				
Nettles, stinging	<i>Urtica urens</i>		X	X											X				
Pansy, wild	<i>Viola sp.</i>														X				
Parsnip, wild	<i>Sium suave</i>				X												X		
Peppergrass, field	<i>Cardaria draba</i>															X			
Pennycress	<i>Thlaspi arvense</i>													X	X				
Pigweed, prostrate	<i>Amaranthus retroflexus</i>	X																	
Pigweed, red root	<i>Amaranthus retroflexus</i>			X															
Pineapple weed	<i>Matricaria matricarioides</i>													X					
Pinks	<i>Dianthus sp.</i>					X													
Plantains	<i>Plantago sp.</i>		X	X									X	X					
Radish, wild	<i>Rapranus raphanistrum</i>				X										X		X		
Ragwort, tansy	<i>Senecio jacobaea</i>		X																
Rape	<i>Brassica haps</i>					X													
Rape, bird														X					
Redshank	<i>Polygonum periscaria</i>		X																
Robin, ragged			X																
Rose family	<i>Rosa sp.</i>					X													
Rushes			X																
Salad burnet	<i>Poterium sanguisorba</i>															X			
Salep																X			
Scarlet Pimpernel	<i>Anagallis arvensis</i>															X			
Sea Plantain																		X	
Sedges	<i>Cyperaceae sp.</i>		X																
Shepherd's purse	<i>Capsella bursa-pastoris</i>											X							X

continued

Source: Robert Kourik ~ 'Designing & Maintaining your Edible Landscape Naturally'

SOIL INDICATORS

Common Name	Botanical Name	Dry	Wet	Cultivated/Tilled	Uncultivated/Neglected	Low N	High N	Low K	High K	Low P	High P	Sand	Clay	Hardpan/Crusty	Acid	Alkaline	Low Fertility	High Fertility	Salty
Silverweed			X																
Smartweeds	<i>Polygonum scabrum</i>		X																
Sorrel, garden	<i>Rumex sp.</i>		X													X			
Sorrel, sheep	<i>Rumex acetosella</i>											X			X				
Sow thistle	<i>Sonchus arvensis</i>												X		X				
Speedwell	<i>Veronica sp.</i>	X		X															
Spruce, leafy	<i>Euphorbia esula</i>	X																	
Spurges	<i>Euphorbia sp.</i>			X															
Spurry, corn	<i>Spergula arvensis</i>											X			X				
Stinkweed	<i>Thlaspi arvense</i>													X		X			
Strawberry, wild	<i>Fragaria sp.</i>															X			
Sundews																X			
Thistle, Canada	<i>Cirsium arvense</i>												X						
Thistle, nodding	<i>Carduus nutans</i>															X			
Thistle, Russian	<i>Salsola pestifer</i>	X																	X
Toadflax	<i>Linaria vulgaris</i>												X						
Vetches	<i>Vicia sp.</i>					X													
Water hemlock, spotted	<i>Cicuta maculata</i>		X																
Watercress	<i>Nasturtium officinale</i>		X																
Willow, black	<i>Salix sp.</i>		X																
Wormwood, biennial	<i>Artemisia biennis</i>				X				X								X		
Yarrow	<i>Achillea millefolium</i>							X											

Source: Robert Kourik ~ 'Designing & Maintaining your Edible Landscape Naturally'

SOME SOIL INDICATOR PLANTS ³⁰			
Trees & Shrubs			
Wet	Well Drained	Acid	Alkaline
Common alder*	Bramble	Rhododendron*	Wild clematis*
Willows†	Wild privet	Heather*	Wayfaring tree
Guelder rose	Wayfaring tree	Bilberry, blueberry*	Yew
Bog myrtle	Juniper	Broom	Whitebeam
		Scots pine	
Dry			High Nutrients
Gorse			Elder*
Broom			Wild cherry, gean
Herbaceous Plants			
Wet	Well Drained	Acid	Alkaline
Rushes*	Bracken*	Sheeps sorrel*	Charlock
Horsetail	Campions	Common sorrel	Rockrose
Silverweed	Sheepsbit	Lesser stitchwort	Salad burnet
Creeping buttercup	Agrimony	Tormentil	Common poppy
Coltsfoot	Salad burnet		Wild basil
Moist	Severely Compacted	High Nutrients	Fertile
Mosses*	Silverweed	Common orache	Stinging nettle*
Chickweed	Great plantain	Charlock	Fat hen*
Great willowherb		Cleavers	Chickweed*
Meadowsweet			Annual mercury
Common fleabane		Low nutrients	Annual nettle
Ragged robin		Wild legumes	Black nightshade
		Spurreys	

* Most reliable indicators. † Not goat willow.
Where a plant is listed under more than one heading, it may indicate either condition, not necessarily both.

* Most reliable indicators.

[†] Not goat willow.

Where a plant is listed under more than one heading, it may indicate either condition, not necessarily both.

Source: Patrick Whitefield ~ 'The Earth Care Manual'

SOIL INDICATOR PLANTS	
Trees and Shrubs	
Alder	*Wet, usually beside a stream or river Indicates land liable to flood
Beech	Well-drained; often suffers from die-back on poorly-drained soils
Bilberry or blaeberry	*Acid, *poor
Bramble	Well-drained but moist
Bog myrtle	*Wet, acid
Broom	Acid, sandy
Chestnut, sweet	Acid, sandy, but often planted on other soils
Elder	Rich, usually alkaline
Elm, suckering	Very typical of clay, but in some areas also on sandy and gravelly soils (see above)
Elm, wych	Alkaline, often on a clay soil over limestone
Gorse, common	Well-drained, usually sandy, poor; but increasingly found on a wider range of soils
Gorse, dwarf and western	Acid, not necessarily well-drained
Guelder rose	Moist to wet, usually alkaline
Heath, cross-leaved	*Acid, poor, wet
Heather, bell	*Acid, poor, dry
Heather, common or ling	*Acid, poor, moist
Old man's beard or wild clematis	*Alkaline
Rhododendron	*Acid
Rowan	Typical of light, acid soils, but very occasionally on limestone

Fleabane	Damp
Foxglove	Acid
Goosegrass or cleavers	Rich
Harebell	Well-drained
Heath bedstraw	Acid
Hemp agrimony	Damp to wet
Horseshoe vetch	*Alkaline, *dry; limestone or chalk
Horsetail	Wet subsoil
Kidney vetch	Well-drained, usually alkaline
Marjoram	Well drained, usually alkaline
Meadowsweet	Moist to wet
Nettle, annual or small	Rich
Nettle, stinging	*Rich, especially in phosphorous
Opium poppy	Rich
Orache	Rich
Pineapple weed	Compacted
Plantain, greater	Compacted
Pyramidal orchid	Alkaline
Ragged Robin	Wet, not very acid
Reed	Usually on soil flooded for at least part of the year
Rush, hard	*Wet, alkaline
Rush, soft	*Wet, acid
Salad burnet	Alkaline, dry
Sheep's sorrel	*Acid, dry
Silverweed	*Compacted or damp
Sorrel, common	Poor

Scots pine	Acid, but often planted on other soils
Spindle	Alkaline
Wayfaring tree	*Alkaline
Whitebeam	Well-drained, limestone or light sands
Willows, except goat willow	Wet
Yew	Especially common on chalk, but also on other well-drained soils
Herbaceous	
Agrimony	Well drained
Birdsfoot trefoil	Low nitrogen
Bog asphodel	Wet, *acid and *poor
Bracken	*Well-drained, usually acid, usually sandy when abundant
Buttercup, bulbous	Well-drained
Buttercup, creeping	Moist, compacted or heavy
Buttercup, meadow	Moist
Chickweed	Rich
Coltsfoot	Heavy
Cow wheat, common and small	Acid
Orchid, pyramidal	Alkaline
Corn spurrey	Poor, acid
Cuckoo flower or lady's smock	Moist
Deadnettle, white & red	Rich
Dock, broad leaved	*Rich
Fat hen	Rich

Stinking iris	Alkaline
Thistle, creeping	Often compacted subsoil, fairly rich
Thyme	Dry, usually alkaline
Tormentil, common	Acid, poor
Willowherb, great hairy	Damp
Wood sorrel	Usually acid

Source: Patrick Whitefield ~ 'The Living Landscape'