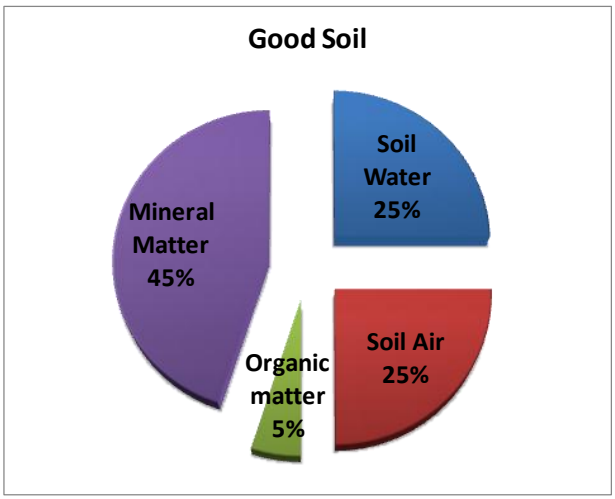
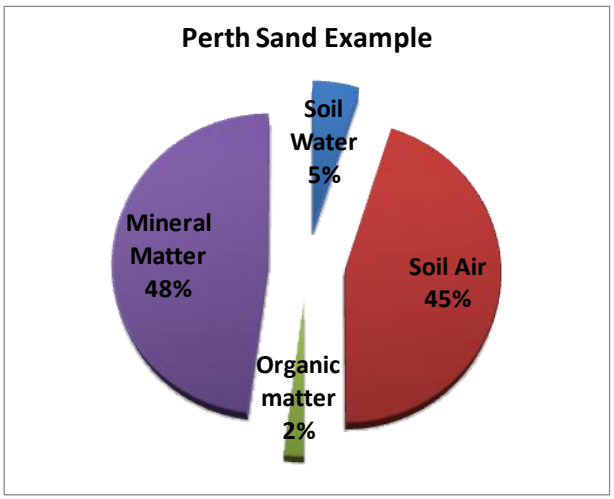
Soil Basics

- Soil should be considered and treated as a single, but large living organism.
- Needs (similar to the human body) -
    - water, air
    - Nutrient/mineral source
    - building blocks / structure to house it in
    - a stable balance of smaller creatures to fight disease, to aid nutrient digestion and to perform many other processes to maintain overall health.
- To resuscitate the soil so that it requires less continuous maintenance and nutrient replacement, it takes an understanding of all these needs and an appreciation of how the individual parts of the soil work together as a whole.

Soil Composition

Soil Lumps	Soil Gaps
Mineral Matter	Soil Water
Organic Matter	Soil Air





For more information head to: www.terraperma.com.au

1.0 Soil Gaps - Size really does matter!

- Called "pore spaces", these gaps are the free spaces in between the mineral and organic lumps

- They hold C, H, O and N in the form of living creatures, air and water.

- Small soil life (bacteria, fungi) live on the borders of these gaps (on the surfaces of the lumps) where they have access to food (the lump - minerals or organics), air and water. Therefore the surface area of the lumps also plays a key role.

- The larger soil life (worms, ants, nematodes...) create gaps as they move through the soil acting to de-compact and increase the gaps in gap-poor soil.

- The balance between gaps and available surface area for colonisation are directly related to the size of the soil lumps and how they fit together.

2.0 Soil Lump Size (or Particle Size) -

The individual lumps separated and labeled as:

- larger rock fragments - granules, pebbles, ...- >2mm
- Sand - 0.05mm to 2mm (think of the beach, coastal)
- Silt - 0.002 to 0.05mm
- Clay - <0.002mm (very fine, potentially boggy, hills)

Rock melons, peas and poppy seeds.....

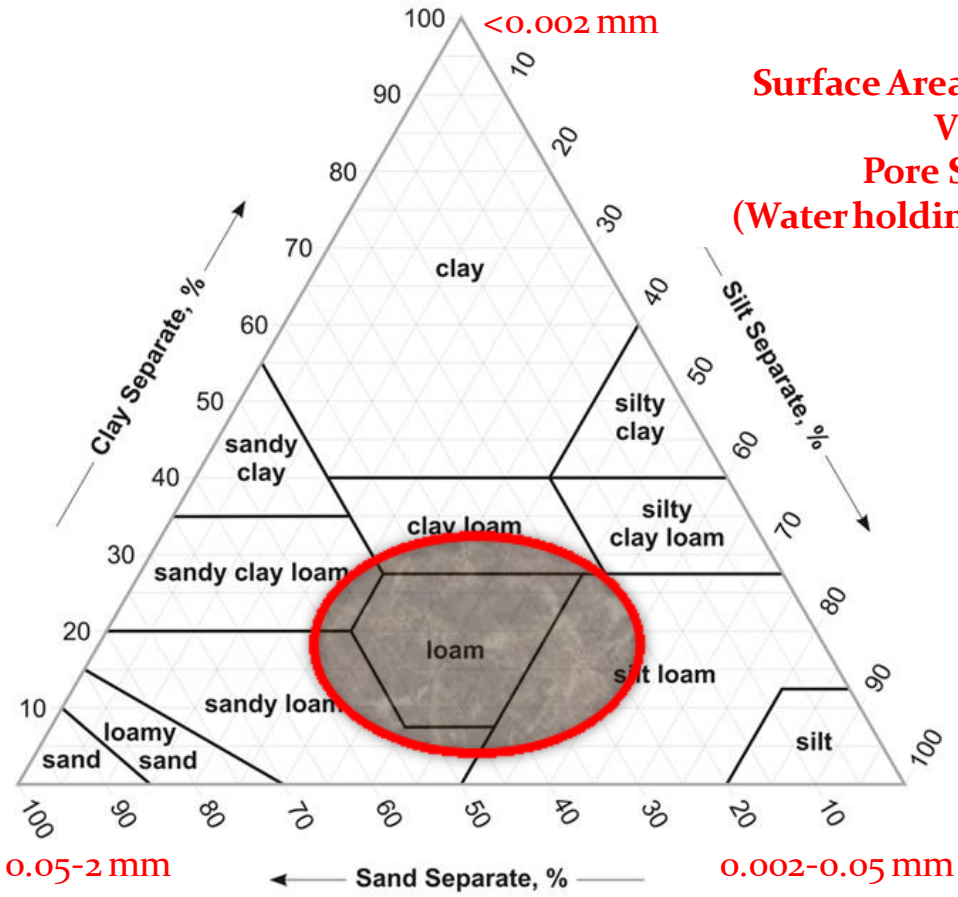
- Big particles (sand and rocks) have large spaces between them when packed, but because not many can fit into a given space, they have a small total surface area - not much living space for bugs and the water (plus nutrients) washes straight through. Think of a bath filled with rock melons - if you poured water in, would it all head straight out the plug hole with very little coating the surface of the rock melons?

- Tiny particles (clay) have tiny spaces between them when packed and because you can fit heaps into a given space, they have a massive surface area - heaps of living space for bugs, but the water gets held by surface tension filling the gaps and causing the 'soil' to remain wet and boggy. Think of a bath filled with poppy seeds - if you poured water in, would it all head straight out the plug hole or would you end up with a stodgy mess - like clay the poppy seeds will likely swell too!

(Remember that air is important too when it comes to bug activity (anaerobic decomposition is not pleasant!). The air is drawn into the soil through the movement of the water down to lower layers, hence the boggy effect suffocates the soil bacteria dependent on air as air pockets can only sustain them for so long.)

- However, what if we fill the bath with rock melons (sand) then add peas (silt) and they fill about 80% of the gaps between the rock melons? We've reduced the gaps and so slowed the water, whilst increasing the surface area. What if we then added poppy seeds (clay) to fill about 80% of the gaps between the rock melons and the peas? Again we've reduced the gaps and so slowed the water flow, whilst increasing the surface area.

Getting the balance between the sand, silt and clay is important for water holding (but not flooding); nutrient/mineral/fertiliser/bug food holding and, as a result, soil life maintaining. So what are we aiming for and how do we get it.....



Loam is the aim and any movement towards it and away from our sandy coastal soil is a step in the right direction.

Texture amendment is the first step to improving your soil to prevent other improvements being washed away or the soil life and plants perishing due to rotting in boggy soil (we wish!).

To amend sandy soil, clay addition is the key to moving away from the left bottom corner of the "Soil Texture Triangle".

Bentonite clay is recommended to be blended into the soil. Blend it in dry to avoid clumping. If you cannot blend it in, then spread it finely across the "sand" surface and mulch over it before wetting. Watheroo Bentonite WA is sold as 80% pure bentonite and when comparing the price per recommended application rate works out significantly cheaper that other blended clay products.

3.0 Soil Lumps - Minerals - Variety, Variety, Variety

So what is important about the lumps (and apart from their size), why do we care?

The majority of the lumps are the minerals the plants need to grow, flourish, and bear fruit.

Mineral types:

- Macro Nutrients - Required by plants in large amounts.

  Nitrogen, Phosphorus, Potassium, Sulphur, Magnesium, Calcium.

- Micro Nutrients (Trace Elements)

  Essential - Plant cannot complete its lifecycle without small amount.

  Iron, Manganese, Boron, Zinc, Copper,....

  Beneficial - can compensate for too much or too little of another mineral

  Cobalt, Silicon

Like our body, plants and soil life needs a wide variety of minerals to function. Some are not able to be absorbed without the presence of other minerals; the absence of some can be as catastrophic as cell wall failure or an inability to photosynthesize; and the accessibility of some are dictated by other factors like soil pH and the mineral to organic matter ratios. Some mineral deficiencies you can get away with as other minerals can compensate.

Like our body, however, too much on anything is bad with excessive specific nutrients in the soil leading to toxicity.

It can get pretty complicated if you are trying to define what you lack, but the answer is very simple.

3.1 How can we help?

The answer is Long term / Slow Release Macro- & Micro-Nutrients in the form of **Rock Dust** or similar product. Toxicity is avoided and a wide range of minerals are delivered over an extended period of time with one application..... and with our clay in the soil we know the minerals will not be washed away.

Rock dust is usually a mixture of granite and basalt rocks and is normally recommended to be applied at 1-2 handfuls per square metre.

Contains: Nitrogen, Phosphorous, Potassium, Calcium, Carbon, Magnesium, Sulphur, Silicon, Iron, Copper, Zinc, Manganese, Boron, Cobalt, Molybdenum and Selenium in a balanced, slow release form. (The Green Life Soil Company)

Some producers bond it with beneficial microbes (bacteria & fungi) to innoculate the soil and help establish healthy microbial populations.

Supply Options - The Green Life Soil Company, No Frills Fertilisers, or other local seller.

Kelp (or sea minerals) is the other addition that will deliver even more minerals and it is reported that its application:

- "enhances plant productivity and quality – root and foliage growth, flowering, fruiting (evenness of fruit set, sugar content, etc).
- improves tolerance to heat, drought and frost conditions.
- assists a plants natural resistance to insect and fungal attack.
- optimises balanced plant nutrition with a broad range of trace elements and minerals."

Buying it in dry flakes is far cheaper per volume of actual kelp you get, but mixed liquid products work well too.

Supply options – Eco-seaweed, Seasol, etc

If Rock Dust was like us taking a long term vitamin tablet then kelp is drinking gatorade for faster action and performance (but with a slightly longer garden

buzz especially when in flake form). It is a general growth, health and energy stimulant.

E.G.:

CHEMICAL ANALYSIS OF SEASOL LIQUID SEAWEED

The analysis below has been compiled from several sources including analyses carried out by the Department of Agriculture, Mt. Pleasant Laboratories, Launceston, The Government Analyst in Hobart, Tasmania and the Research School of Chemistry, Australian National University, Canberra.

Tri Indole Acetic Acid (IAA)	154 micrograms per lt	Magnesium (Mg)	0.04% w/w
Trans-Zeatin-Riboside (Zr)	7.0 micrograms per lt	Sulphur (S)	0.2% w/w
Isopentenyl Adenosine (IPA)	2.0 micrograms per lt	Cobalt (Co)	0.40 p.p.m
Trans-Zeatin (Z)	0.7 micrograms per lt	Boron (B)	13 p.p.m
Isopentenyl Adenine (IP)	16.0 micrograms per lt	Iron (Fe)	300 p.p.m
Bacterial Activity	8 x 107 cells/g	Flouride	24 p.p.m
Ash (Mineral Content)	10.2% w/w	Manganese (Mn)	5.4 p.p.m
Organic matter (Solids minus Ash)	10% w/w	Zinc (Zn)	32 p.p.m
Water Content	76.8 %w/v	Copper (Cu)	0.64 p.p.m
Total Nitrogen	0.22% w/w	Nickel (Ni)	2.0 p.p.m
Ammonia Nitrogen	156 mgm/kg	Molybdenum (Mo)	3 p.p.m
Nitrate Nitrogen	46 p.p.m	Aluminium (Al)	30 p.p.m
pH Value	9.5 – 10.5	Selenium (Se)	0.02 p.p.m
Specific Gravity 20°C	1.08	Silver (Ag)	0.02 p.p.m
Free Alkalinity (as KOH)	0.06% w/w	Vanadium (Vd)	0.08 p.p.m
Phosphorus	0.58% w/w	Iodine (I)	120 p.p.m
Potassium (K)	4.3% w/w	Mercury (Hg)	0.008 mgm/kg
Sodium (Na)	0.9% w/w	Polychlorinated Biphenyls	<0.001 mgm/kg
Chloride (Cl)	0.33% w/w		
Calcium (Ca)	0.098% w/w		

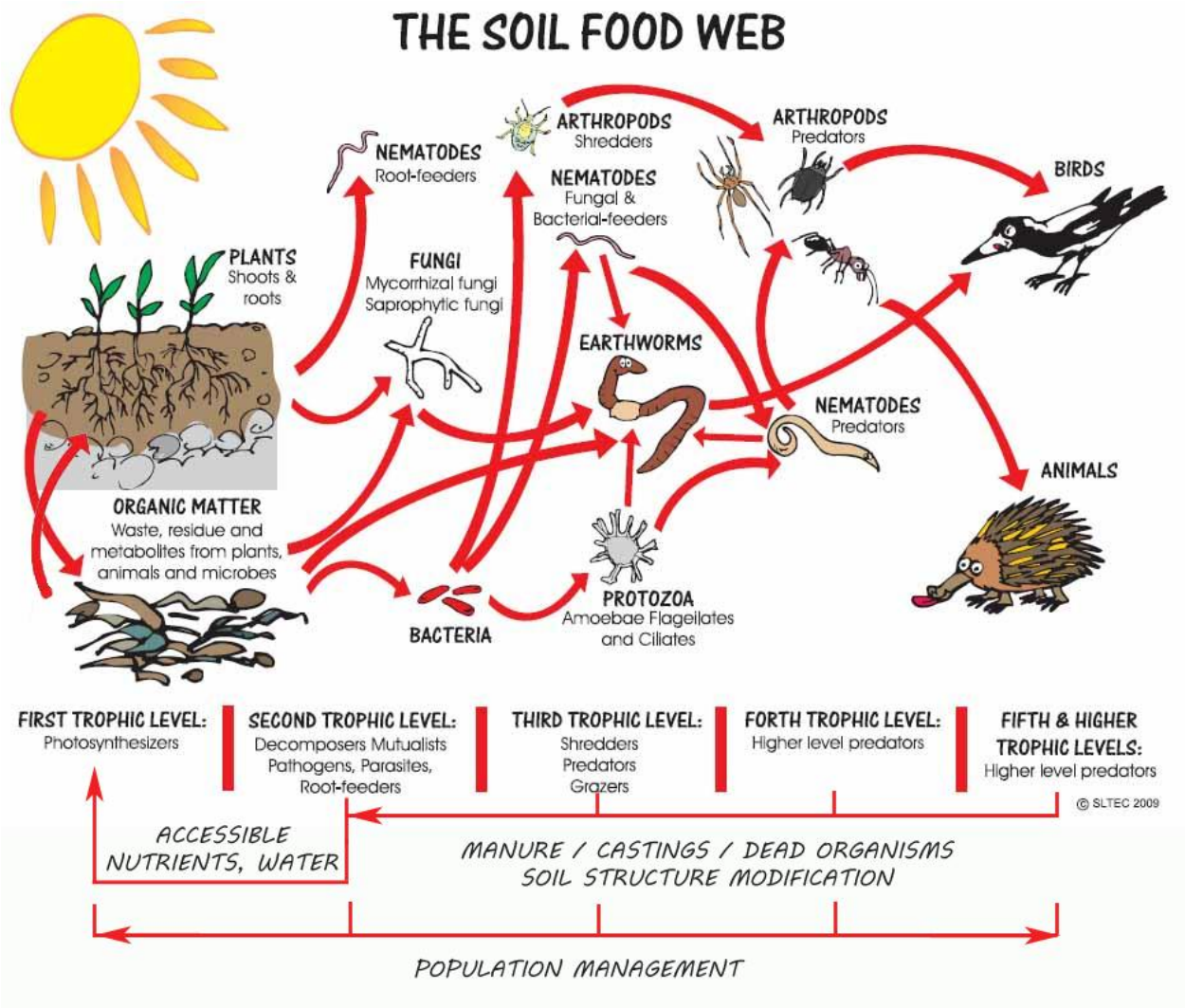
4.0 Soil Lumps - Organics - Wanted Dead or Alive

Now **Organics** in this context does not mean "certified organic", but just that either it is alive or at one point it was alive - from seeds to roots to trunk to leaves; bacteria to echidnas; from the leaf at the top of the tree photosynthesizing to the decomposing leaf under a pile of other leaf litter; from animal poop to a fingernail clipping - you name it, if it had life at any point it is carbon based and by definition ORGANIC.

So what role to the organic lumps play.....

We've talked about the life on the surface of the lumps (they too are part of the organic piece of pie) and, depending on what type they are, these bacteria and similar sized life consume anything and everything. They help weather the minerals with the help of water to make them accessible to the plants. They eat dead (and sometimes not so dead!) organic matter and make the nutrients stored in that accessible to the plants. There are larger types of soil life that then feed on these tiny guys to control their population and make their minerals available to the plants. And so the food chain continues.

This food chain however is normally described as a food web, as the passage of nutrients does not just flow the one way. The Soil Food Web is best described schematically.



- (Reference: http://sltec.com.au/sustain-gro/, The Soil Hugger's adaptation)

One other key point to note are that it all depends on the sun and the plants photosynthesizing to put energy into the system.

5.0 What else?

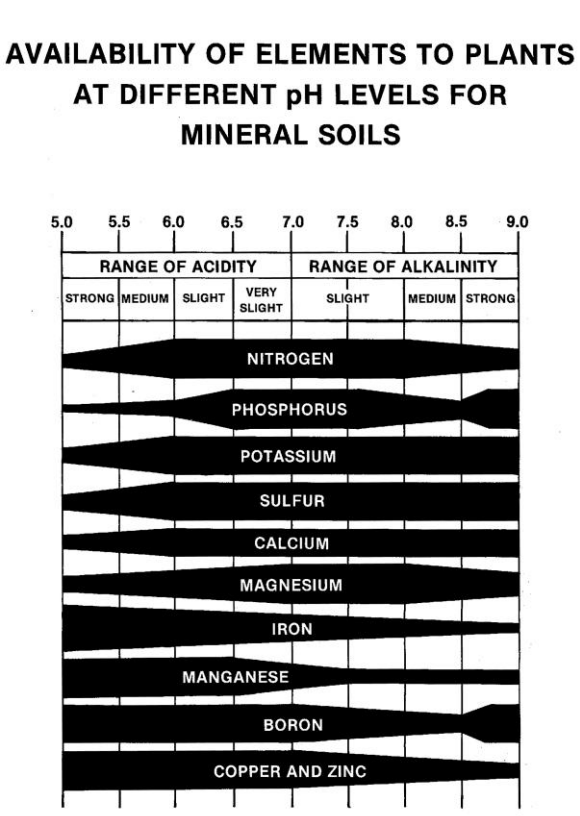
Note that even with all the above nutrients added, the uptake of the nutrients by the plants can be effected by a huge array of other factors, but while it can appear complicated, the answers are still simple.

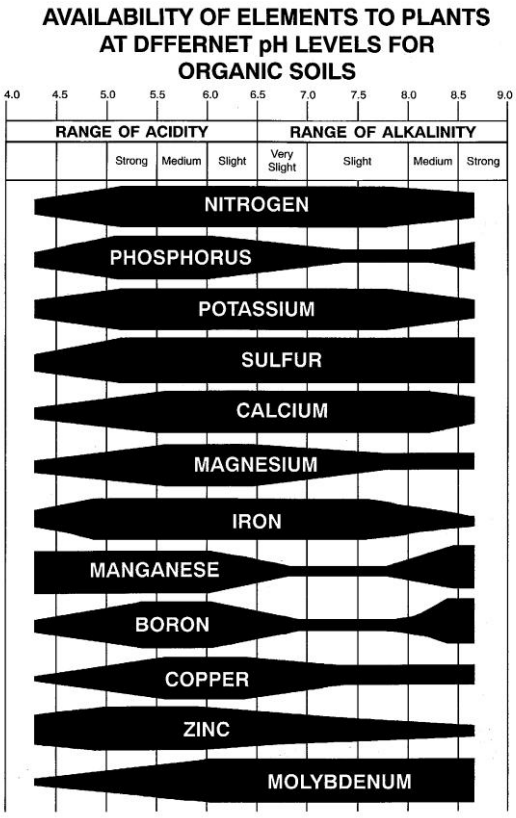
Here are just a few of the other influences.....

5.1 pH

Soil pH refers to the acidity (<7) or alkalinity (>7) of the soil. The addition of chemicals to change pH tends to cause more significant short term fluctuations in pH whilst the application of organic matter migrates pH gradually and is regulated by the bacteria who thrive within a limited pH range.

Optimum soil fertility is typically pH neutral (6.0-7.2) and the availability of minerals as mentioned previously is dependent on being in this general area.





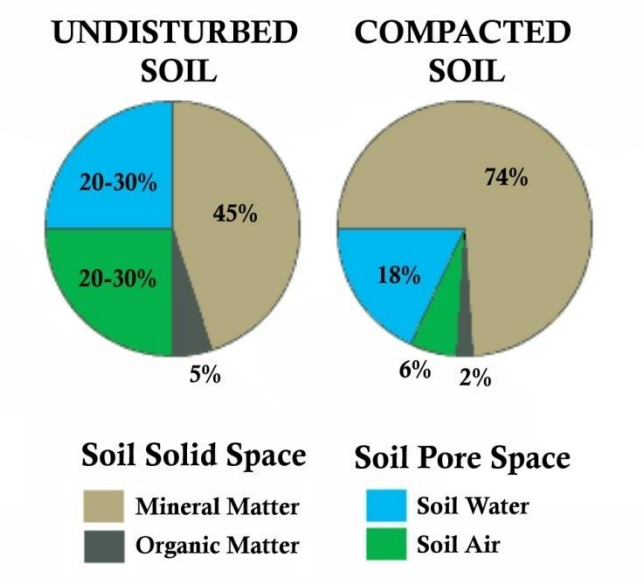
- (Reference: http://www.spectrumanalytic.com/doc/library/articles/soil_buffer_ph)

In very general terms:

- Bacteria like a neutral/7 pH and are depleted <5 or >9.

- Fungi prefer acidic/5 pH, but can exist between 2-7.
- Organic matter mineralization is accelerated as neutral pH is approached due to better microbial activity linked to happy bacteria.
- Nitrification and nitrogen fixation are also inhibited by low pH.

5.2 Compaction



- (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/water/?cid=nrcs144p2_057473)

Compacted or heavily compressed soil restricts root growth by limiting the gaps (water and air), reduces the available surface area (the living space for soil life) and the act of compacting damages roots and fauna.

5.3 Temperature

Extremes of temperature impact soil life - like us, they will move away or perish if the period of exposure is too long. Rapid fluctuations are also a problem.

Whilst we can't control the air temperature, we can protecting the exposed earth from the sun's heat or the winter frost - consider it getting under shade or putting a blanket on. Otherwise, those bugs that can travel fast enough will dive down or head away, those that can't will become food for those that return once the extreme conditions have passed. Either way, for the plants that can't move not only are they being beaten by the heat from above by the sun, from below by the reflected heat off the warm earth, but their canteen is closed too! Add to this the fact that water will evaporate faster from the soil at

high temps and you have a very unhappy garden. Extreme colds, less often a problem for us by the coast, has a similar overall effect via a very different chilly path.

Cover the soil across all seasons with living protection (ground covers, bushes, trees etc) in the long term and/or mulch in the short term.

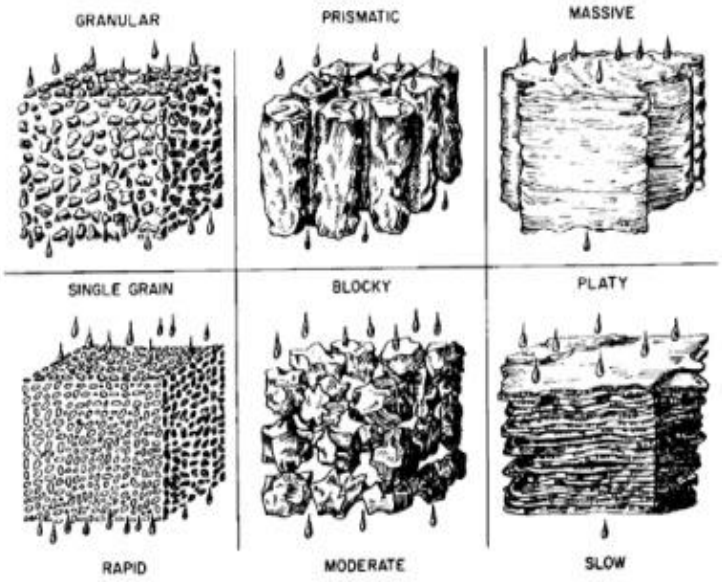
Note that:

- More organic matter means more heat holding, darker colour and more decomposition – increasing temperature.
- Tilled soil is more prone to extremes - cold air able to infiltrate and greater exposure to solar radiation.

5.4 Structure

Looking at the shapes the particles form when clumped together as "aggregates". Soil bacteria, fungi, chemicals released by the roots and static charge caused by water flow cause the individual particles to clump together.

This clumping impacts water flow and retention, pore spaces, young root development and the crust on top of the soil which can stop seedlings reaching the surface.



- (Elements of the Nature and Properties of Soils, Brady, N.C. and Weil, R.R., 2004)

Soil Objective Summary

- We need to look closely at:
    - the ability of water to infiltrate and to be held in the soil; and
    - the nutrient availability within the root zone of the plants we wish to nurture.
- Our goal should be, as close as is practical:
    - Loamy soil;
    - with lots of nutrients and
    - a high living organic content to make those nutrients available;
    - with medium density (not compacted), and
    - covered to protect it from damaging forces (solar radiation, frost, larger order predators, compaction mechanisms…)
- Once established the system should require limited input of energy and mineral sources.

Soil Resuscitation – Talk the Tork

- **T Texture** – develop texture aspiring to loam
- **O Organics** – Fine (compost) and Coarse (Mulch)
- **R Rock Dust** – Longterm Macro- & Micro-Nutrients
- **K Kelp** – Introduce Sea Minerals

Chose locally available, ethical, economical substitutes to fulfill same function.

Soil Testing

- Jar Shake Test
- pH Test