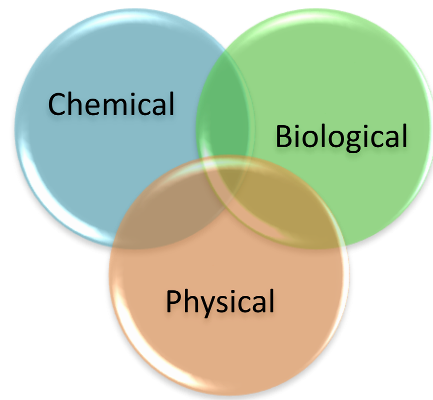
SOIL HEALTH WORKSHOP WITH NICOLE MASTERS, INTEGRITY SOILS, NZ

What is soil? Most simply, soil is a mixture of broken rocks and minerals, living organisms, and decaying organic matter called humus. Humus is dark, soft and rich in nutrients. Soil also includes air and water.

Soil is our most important land asset. Along with sunlight and water, soil provides the basis for: all terrestrial life; the biodiversity around us; the field crops that we harvest for food and fibre. Healthy soils provide ecosystem services, supports healthy plant growth, resists erosion, stores water, retains nutrients, and is an environmental buffer in the landscape.

AIR, WATER AND ORGANIC MATTER (CARBON) are often the major limiting factors for production. Plants and organisms in the soil need air and water to survive and to exchange nutrients and gases.



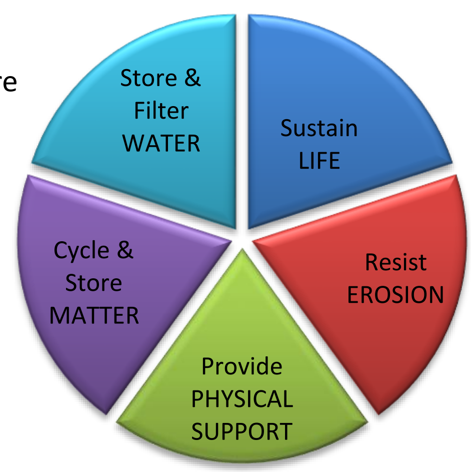
WHAT IS SOIL HEALTH?

A healthy soil is productive, sustainable and profitable. Soil health is the condition of the soil in relation to its capability to sustain biological productivity, maintain environmental quality, and promote plant and animal health. Healthy soils are a result of the complex interaction between physical, chemical and biological processes.

Understanding, protecting and improving soil health is critical for managing your natural assets. Soil health fundamentally links to land productivity and environmental sustainability now and into the future.

A HEALTHY SOIL:

- Buffers plants against climactic extremes; temperature, moisture
- Allows water to infiltrate freely and stores water
- Supplies nutrients, water and oxygen for healthy plant growth
- plus plant growth hormones, vitamins and enzymes
- Resists erosion
- Retains nutrients
- Readily exchanges gases with the atmosphere
- Acts as an environmental buffer; detoxify and filter
- Resists disease
- Contains a large and diverse population of soil biota
- Is not acidifying or salinising
- Has a range of pore spaces to house organisms, nutrients & water



Soil health is the balance of natural soil properties, uncontrollable environmental conditions, and management practices: **management has a major influence on what level of soil health occurs.**

The maintenance of good soil quality is vital for the environmental and economic sustainability of farming. A decline in soil quality has a marked impact on plant growth and yield, crop quality, animal health, production costs, water/nutrient holding capacities and the increased risk of soil erosion. A decline in soil physical properties in particular takes considerable time and cost to correct. Safeguarding soil resources for future generations and minimizing ecological footprints are important tasks for successful long term land management.

GIVE YOUR SOIL A HEALTH CHECK

Do you:

- Make decisions based on soil conditions (too wet, too dry)?
- Manage grazing for optimum plant recovery and diversity?
- Maintain at least 80% ground cover all year round?
- Minimise cultivation and traffic?
- Monitor soil and plant health?
- Buffer nutrients and Ag chemicals with carbon sources?
- Know how deep crop and pasture roots are growing?
- Know how many pests are grazing on your pasture above and below ground?
- Walk the paddocks and observe soil conditions?
- Think about how to invest in soil health as part of your farming business?

If you answered “no” to any of these questions, your soil may be overdue for a health check.

10 STEPS TO OPTIMAL SOIL HEALTH AND RESILIENCE

1. **Avoid costly production losses through building on local knowledge** - Find a mentor: a successful farmer, biological consultant or join a discussion group.
2. **Benchmark:** measure where you are now; soil mineral, biology, leaf tests and photographs.
3. **First do no harm:** reduce and then eliminate products that blow the microbial bridge; soluble N and P, glyphosate, fungicides. Buffer chemicals with microbial foods (e.g. Humic/fulvic acid)
4. **Observe:** pests, weeds and diseases are all indicators for imbalances.
5. **Address major limitations;** air, water, foods and minerals: 1. Drainage, 2. Soil structure 3. Review soil chemistry.
6. **Apply** broad-spectrum products which feed biology and address major nutrient deficiencies, i.e. Lime, RPR, guano, seaweed, fish, seawater, compost, vermicast, sugar etc.
7. **Health:** Ensure crop and animal health needs are being met, if not, use free choice minerals and foliars
8. **Implement** practices that increase photosynthesis, rooting depths and soil carbon.
9. **Monitor and observe changes:** Brix, EC, pH, photographs. Adjust programme as required.
10. **Encourage biodiversity above and below ground:** herbal leys, fodder crops, inter-planting.

VISUAL SOIL ASSESSMENT or VSA Method.

Often, not enough attention is given to:

the basic role of soil quality in efficient and sustained production;
the effect of the condition of the soil on the gross profit margin;
the long-term planning needed to sustain good soil quality;
the effect of land management decisions on soil quality.

Visual Soil Assessment is based on the visual assessment of key soil 'state' and plant performance indicators of soil quality, presented on a scorecard. With the exception of soil texture, the soil indicators are dynamic indicators, i.e. capable of changing under different management regimes and land-use pressures. Being sensitive to change, they are useful early warning indicators of changes in soil condition and as such provide an effective monitoring tool. The VSA looks at the following characteristics:

Soil indicators	Plant indicators
Soil texture	Clover nodules
Soil structure	Weeds
Soil Porosity	Pasture growth
Number and colour of soil mottles	Pasture colour and urine patches
Soil Colour	Pasture utilisation
Earthworms	Root length and density
Soil smell	Area of bare ground
Potential rooting depth	Drought stress
Surface ponding	Production costs to maintain stock
Surface relief	

Sampling Guidelines

It is important to gain as much information about the area and soils as possible. Indicators of soil quality must be evaluated within the context of site and climatic characteristics.

Important: When, where, and how deep to sample and how many samples to take is primarily dependent on the questions being asked or problems being addressed by the farm or land manager. Timing of sampling is important, because soil properties vary within a season and with management operations, such as tillage. In general, for the overall assessment of soil quality, sampling once a year will allow for the detection of long term changes in soil quality. A good time of year to sample is when the climate is most stable and there have been no recent disturbances, e.g after harvest or the end of the growing season. Record the site using a GPS.

Where to sample? An important consideration in determining where to sample in a field is the variability of the area. Soil properties naturally vary across a field and even within the same soil type. Soil variability across a field is also affected by management operations. Avoid areas such as stock camps, troughs and gateways.
VSA booklets, written by Graham Shepherd are available online from Landcare Research: *www.**landcareresearch**.co.nz/**research**/soil/**vsa**/fieldguide.asp* or can be ordered from:

gshepherd@bioagrinomics.com

SOIL MICROBES AND THEIR ROLES

Organism	Description	Role in soil	Foods or innoculation
Bacteria	Bacteria are the oldest, the simplest, and the most numerous forms of life.	Disease suppression, make the smallest microaggregates, **NUTRIENT RETENTION** Decomposers. Make alkaline secretions – creates soil alkalinity.	Aerobic compost tea, good compost. FEED: Nitrogen: green plant materials. Simple sugars, simple proteins, simple CHO. Molasses, fruit juice, seaweed,
Actinomycetes	Long chains of bacteria	Produce antibiotics; disease suppression, nitrogen cycle, humus formation, give soils their 'healthy smell'.	Consume difficult substances such as chitin (e.g. insect shells) and cellulose. FEED: mussel shells, woodier plant materials
Fungi 2 main types: Saprophytes =decomposers Mycorrhizae **(AM)** (=*Fungus root)* plant symbiote.	Grow from spores. Contain long strands of various lengths = hyphae. Food digested externally. Over 90% of all plant species depend upon an AM relationship for health and survival.	Fungi (and bacteria) are the primary decomposers of organic matter. Disease suppression, **NUTRIENT RETENTION** (esp. Ca), make macroaggregates – hold soil together = **EROSION CONTROL** Make organic acids – creates more acid soil conditions.	FEED: Carbon: wood, paper, cardboard. complex sugars, complex proteins, fish oils, fish hydrolysate, cellulose, humic acids.
Protozoa	Single celled organisms. 3 gps: Flagellates, Amoebae Ciliates	Consume bacteria - cycle nutrients. Make air passageways. Important food source for micro-invertebrates. **NUTRIENT CYCLING**	Aerobic compost tea, good compost, straw infusions.
Nematodes	Non-segmented worms. One of the simplest animal groups. Most are beneficial.	Nematodes generally eat bacteria, algae, fungi, protozoa and each other. **NUTRIENT CYCLING.** Release N, P, S and micronutrients during their digestive process.	Aerobic compost and compost teas. Vermicast. Encourage good diverse bacterial/fungal populations to feed nematodes.

SUMMARY: Without bacteria and fungi – most inorganic nutrients added will just wash away!
Without protozoa and nematodes – nutrient cycling from bacteria and fungi to the plant will not occur.
How about the microarthropods and earthworms? Diversity is KEY.

Management considerations

Grazing— proper management and grazing timings of pasture is the best strategy for building the benefits of the soil food web. Encouraging diverse pasture species helps to build soil structure and feed soil organisms. Between 30-60% of the plant sugars (CHO) produced by photosynthesis are sent out through the root zone, accumulating stable carbon deeper in the soil. When plants are grazed, root biomass is also shed into the soils; as roots are 40% carbon this is an important food source for microbes. Keeping livestock moving to new pastures is key to optimal grazing health, productivity and building soil carbon (think of wolves moving buffalo in the wild).

Over grazing – overgrazing is not a one off event, but rather the return to grazing to a plant before it has fully recovered. Overgrazing shifts the species composition, selecting for weeds, non-legume and shorter rooting species. When the plant community is overgrazed, the amount of surface plant material and roots is reduced, producing less food for soil organisms. This starts a downward spiral in soil services, reducing organic matter and impeding nutrient cycling, water infiltration, and water storage.

Erosion—Erosion removes or redistributes the surface layer of the soil, the layer with the greatest concentration of soil organisms, organic matter, and plant nutrients. The key organism in holding soils together is **fungi.**

Bare ground – is one of the most damaging practices for your long term soil health. Puts microbes and invertebrates on a starvation diet, reduces organic matter and releases soil carbon to the atmosphere. Mycorrhizae require plant roots for survival, they can be long lived and extend throughout your pastures. They provide a major pathway for phosphate, zinc and nitrogen to your crop and sequester carbon deep in the soil.

Compaction - Soil compaction reduces the larger pores and pathways, thus reducing the amount of habitat for nematodes and the larger soil organisms. Compaction can also cause the soil to become anaerobic, increasing losses of nitrogen to the atmosphere. Compaction can be due to soil nutrient imbalances, vehicle or animal impacts. Even sandy soils can become compacted!

Fire and pest control -Fire can kill some soil organisms and reduce their food source while also increasing the availability of some nutrients. Pesticides that kill above-ground insects can also kill beneficial soil insects. Herbicides and foliar insecticides applied at recommended rates have a smaller impact on soil organisms. Fungicides and fumigants have a much greater impact on the soil organisms.

SOIL HEALTH IS NOT AN END IN ITSELF

The ultimate purpose of assessing soil quality is not to achieve high aggregate stability, biological activity, or some other soil property. The purpose is to protect and improve long-term agricultural productivity, water quality, and habitats of all organisms, including people. We use soil characteristics as indicators of soil quality, but in the end, soil quality must be identified by how soil performs its functions.

We need more stable and resilient farm ecosystems to reduce our vulnerability to climactic extremes.