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INDEPENDENT STRATEGIC ANALYSIS OF AUSTRALIA'S GLOBAL INTERESTS

Strategic Analysis Paper

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Regenerating our Landscapes

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Key Points

- Much of Australian soils are old and weathered. This has partly resulted in depleted levels of biological activity, reduced carbon flow and lower than average rainfall retention.
- Regenerative practices are essential; without water, carbon, nutrients and critical microbes, and an effective relationship between them, soils will continue to deteriorate.
- Healthy soils result from a range of conditions, including substantial ground cover and plant litter.
- Appropriately sequestered (drawn down from the atmosphere), soil carbon is vital to improve and maintain the water holding capacity of soils and their nutrient status.
- Healthy soils contain vast numbers of living organisms. Some are visible to the naked eye, such as earthworms and beetles. Others, however, are only visible through a microscope and typically consist of a single cell.
- In general, organic matter enhances the abundance and activity of essential microbes.
- Organic matter in the soil includes a wide variety of living and dead plant and animal residues and well-rotted manure and compost, which are at various stages of decomposition.

Summary

Soil consists of five principle components; water, carbon, nutrients, organisms and organic matter. In healthy topsoil these components, complex in themselves, interrelate in complex ways to create one of the fundamental elements supporting life on the planet. Australian soils are typically deficient in organic matter, nutrients and carbon. Water retention capacity is below average. The activity of microorganism is impeded. Land management practices that promote the positive interaction of these components can promote increased food production, maintain sustainability and decrease the volume of atmospheric carbon.

Analysis

Introduction

This paper seeks to provide a short and simple description of how carbon, water, nutrients, organic matter and microbes interact to underpin the health of soils.

Soil is the outer, loose earth material that differs from the underlying bedrock. It is a mixture of five main ingredients: weathered rock, organic matter, air, water and a myriad of organisms that together support plant life. The weathered rock can be in the form of sand, clay, silt and pebbles. Organic matter can be anything that includes decomposing plant and animal matter. Air and water are vital for organisms to live and grow.

Significant areas of Australian soil are oxidised and weathered. This has contributed to depleted levels of biological activity, reduced carbon flow and lower than average rainfall retention. Much of our agricultural landscape is now characterised by areas of bare earth, eroded waterways, the presence of weeds and a lack of desirable plant species. There is also much agreement that soil health will continue to decline under current management practices and in the face of an increasingly challenging climate.

Nor has the situation been helped by the fact that research has tended to centre largely on increasing yields rather than building new topsoil.

Regenerative practices are essential; without water, carbon, nutrients, critical microbes, and an effective relationship between them, soils will continue to deteriorate. Boosting soil productivity will not only feed future generations but will have a positive effect on climate change and improve our ability to deal with floods, droughts and wildfires.

Of course, some measures are already under consideration or being practised. For instance, degraded areas are being replanted, deforestation is being avoided, wetlands – a source of much carbon – are not being farmed, biomass is being mulched rather than burnt and mangroves and salt marshes are being restored. The question, however, is whether these actions are being implemented in a sufficiently timely and widespread manner?

Building Topsoil

Healthy soils require a groundcover of plants and plant litter. This ensures that temperatures are buffered and that water is absorbed and held more effectively and for longer periods.

Figure 1. Examples of different plant root systems. The photograph on the left depicts soil and root systems typical of many parts of northern Australia. The soil and root systems depicted on the right are more typical of parts of south-eastern Australia and the northern hemisphere.

Plants have roots, shoots, stems and leaves. Each has distinct functions. Together they inhabit soil and air. The soil offers water and vital minerals or nutrients while air provides carbon dioxide to enable sunlight to drive plant growth.

Roots have two major functions: they anchor a plant to a fixed spot and they release carbon into the soil to enable microbes to access and to provide essential nutrients for plant growth. Shoots are the above ground part of the plant and in time develop into stems and leaves. Stems (the trunk, branches and twigs) provide the means by which water and nutrients are transported to the leaves. Leaves absorb carbon dioxide from the air, resulting in the production of carbohydrates through the process of photosynthesis. Carbohydrates are then moved through stems to different parts of the plant, including its roots.

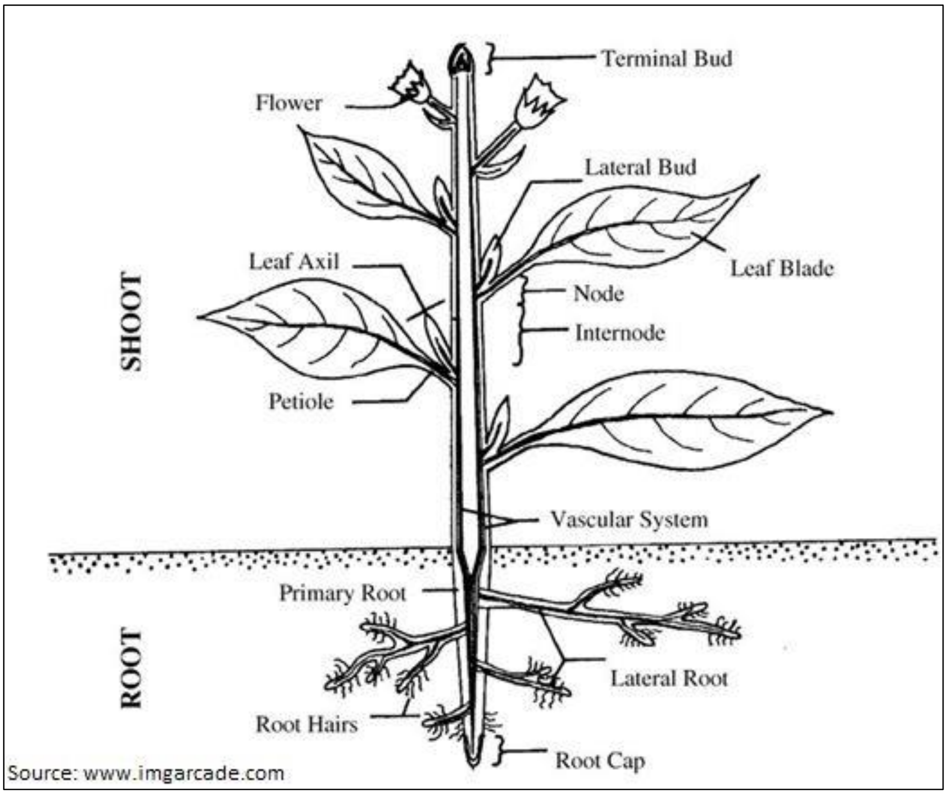

Figure 2. The Principal Parts of a Plant

Soils ideally need to be porous. This results from microbes producing sticky substances that enable soil particles to bind together into crumbs called aggregates. It also ensures that the spaces between aggregates allow the soil to breathe and to absorb moisture. Healthy topsoil, for instance, should have as much space as solid material.

Water

Water is critical for the formation of organic matter and fertile soils. Water enters the soil from above ground through a process known as infiltration. This occurs largely through rainfall and irrigation. Water also moves from below the root systems. Many nutrients are dissolved and moved by water. Most chemical reactions involve water, and it is vital for the development and sustainability of microbes.

Infiltration rates can be near zero in clay and compact soils as opposed to sandy and well-aggregated soils. Low infiltration can also lead to increased surface water run-off. Organic matter, especially crop residue and decaying roots, aids soil structure to allow for more effective infiltration.

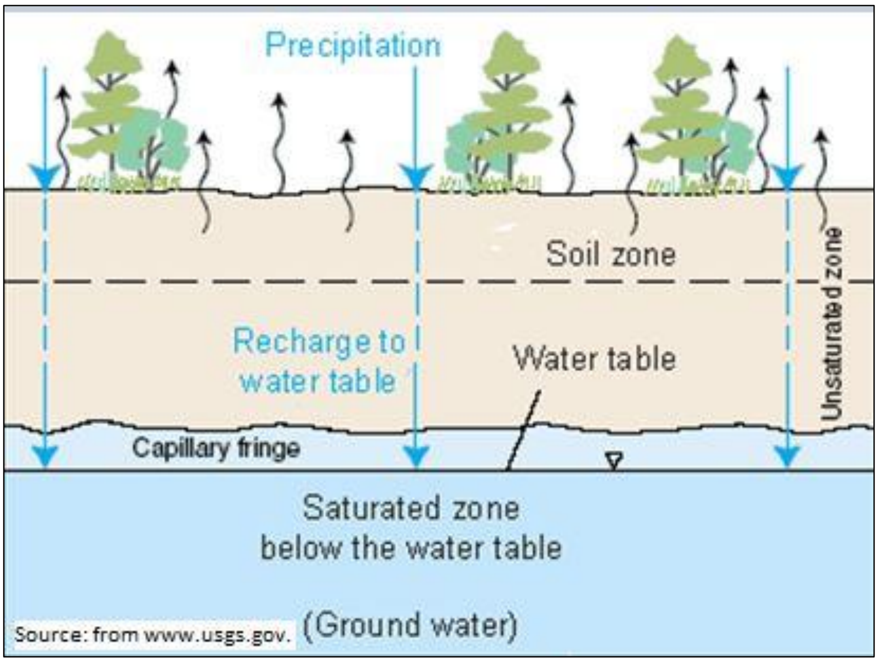

Figure 3. Soil and Ground Water

Water leaves the soil through evaporation or by continuing to infiltrate to in-ground water holding areas or by transpiration during plant growth. Excessive water can rob soils of their nutrients by washing them away, resulting in a process known as leaching.

The capacity of soil to retain and release water depends on a range of factors: soil texture and depth, its architecture including pores and compaction, its organic matter content and biological activity.

Pore space (the gaps between soil particles) is the conduit that allows water to infiltrate and leave. It also serves to hold water.

Carbon

Appropriately sequestered, carbon is vital to improve and maintain the water holding capacity of soils and their nutrient status. Carbon dioxide is sequestered through the process of photosynthesis in green leaves, using the energy of the sun to convert CO_2 and water into glucose and oxygen. Plants form several carbon compounds which, under the action of beneficial microorganisms such as bacteria and fungi, builds humus in soils.

Key to building the soil carbon store is adequate plant or crop residue, a balance of essential minerals, a nitrogen supply such as animal manure and a healthy population of soil microorganisms to do the digestion and sequestration. This process produces thick humic compounds that bind fine soil particles, gradually building larger, visible aggregates.

Humus (a stable form of carbon) plays a vital role in maintaining the structure of soils and the availability of water and nutrients. One part of humus is also believed to hold four parts of water. Expressed differently, a one per cent increase in soil carbon in the top 30^3cm of soil can store up to two additional buckets of water (16.8 litres) in that soil.

Figure 4. Soil rich in humus.

Humus also reduces soil erosion by wind and water because of its role in developing aggregates. It also stores and supplies nutrients, especially nitrogen, phosphorous and sulphur. It increases the water holding of soils. It can also reduce the incidence of some soil-borne diseases and stimulate growth of beneficial soil bacteria, fungi and earthworms. Well-structured soil can aid the leaching of salts to below the root zone and can also aerate soils.

Nutrients

There are 15 essential nutrients a plant must have to properly grow. Three – hydrogen, carbon and oxygen – are obtained from the atmosphere. The remaining 12 come from the soil. Primary nutrients include nitrogen, phosphorous and potassium. Other essential nutrients include sulphur, magnesium and calcium as well as a range of micronutrients.

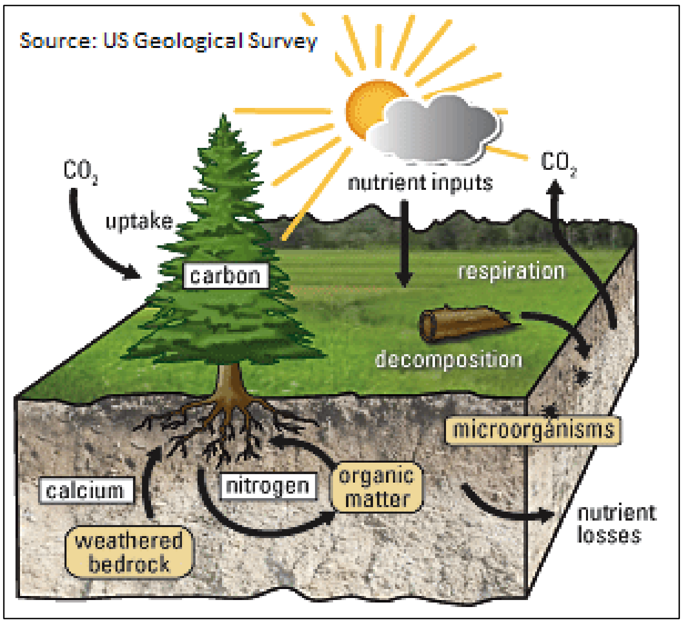

Figure 5. The Nutrient Cycle

Most soils with a healthy microbial life and reasonable levels of humus will provide plants with adequate nutrients and will encourage effective nutrient turnover and availability. Even with adequate water and sunshine, however, nutrient deficiency can limit growth. In Australia microbial activity, humus and nutrient levels are often insufficient to sustain continuous growth.

The root, especially the root hair, especially when associated with fungi, is essential for nutrient uptake. Nutrients move inside a plant to where they are most needed. For example, a plant will try to supply more nutrients to its younger leaves rather than to its older leaves.

Microorganisms

Healthy soils contain abundant living organisms. Some are visible to the naked eye such as earthworms and insects. Others, however, are only visible through a microscope and typically consist of one cell. These include bacteria, viruses and certain algae and fungi. The area of soil located around active roots, called the rhizosphere, is an area of high microbial activity. Material released from roots, as exudates, creates a food-rich environment for the growth of microorganisms that help plants by fixing nitrogen from the air, dissolving soil minerals and decomposing organic matter, all of which allows roots to obtain essential nutrients.

Some microbes have a special role. A kind of fungus called mycorrhizae also associates with plants. By colonising large areas of roots and reaching into the neighbouring soil, mycorrhizae helps to transfer soil nutrients and water to the plant. This is especially important where nutrient availability or moisture is limited. Biological populations can be severely affected by excess chemical fertiliser application and herbicide sprays, as well as the practice of burning stubble.

Source: Michael Rothman

Figure 6. Mycorrhizal Fungi is the principal structure for the uptake of many important plant nutrients in the plant kingdom

Microbes are essential to maintaining good soil structure, which promotes infiltration and drainage of water, soil aeration and vigorous plant growth. Gummy substances produced by microbes help create aggregates which, in turn, contribute to soil structure. Fungal hyphae further stabilise soil structure as their threadlike elements spread through the soil like a hairnet.

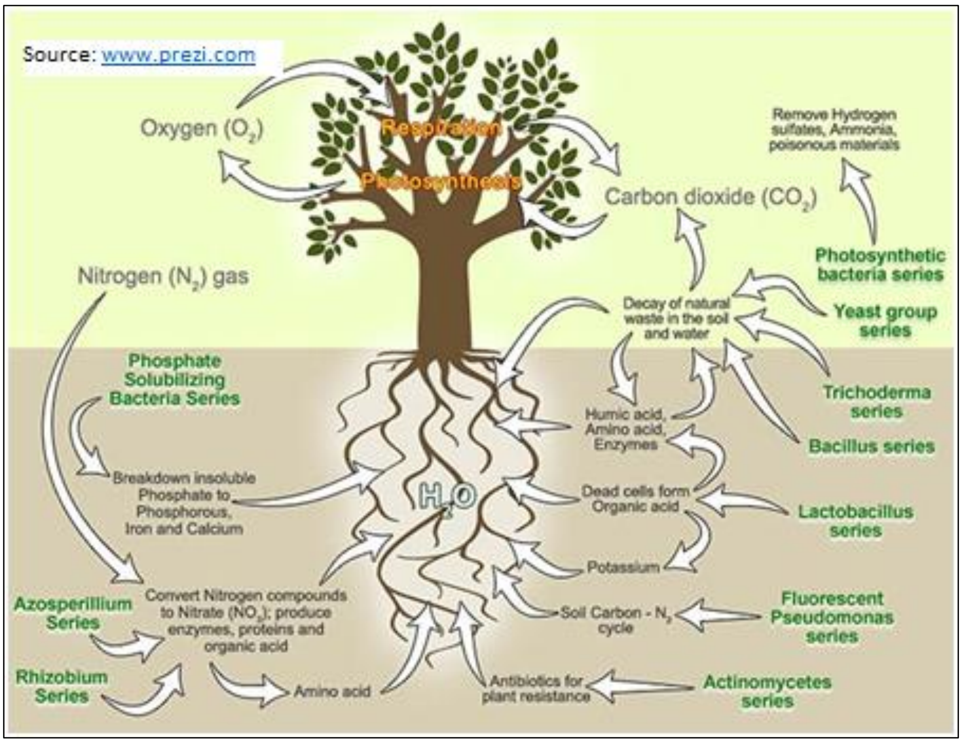

Figure 7. Microorganisms in the Soil

The presence of different kinds of organisms depends on moisture, aeration, the amount of organic matter and the types of plants. Chemical conditions such as acidity and alkalinity will also affect soil organism populations.

To encourage microbial activity, soil must be managed to create a favourable environment for both crops and microbes. Excessive cultivation, inappropriate fertilizers, fallowing (bare soils without growing plants), irrigation and biocides can impede these microbial activities.

In general, the abundance of microbes in soil is proportional to the amount of organic matter.

Organic Matter

Organic matter in the soil (or soil organic matter - SOM) includes a wide variety of living and dead plant and animal residues, ranging from kitchen wastes and shredded leaves to well-rotted manure and compost which are at various stages of decomposition. Organic matter is frequently in the form of humus, which is partly decomposed organic matter that has become dark and crumbly and continues to decompose at a slow rate.

Earthworms mix fresh organic materials with the soil. This brings organic matter into contact with soil microorganisms.

As discussed above, digested SOM is the glue that helps provide structure to smaller particles and, in doing so, prevents compaction and thus leads to an increase in root growth. As a result, soil can absorb more water and is better able to resist erosion by wind and rain. Digested SOM also attracts and holds many soluble nutrients that are then available to the plant. The presence of soil organic matter usually leads to an increase in the number and types of microorganisms which can lead to reductions in plant diseases.

Environmental factors such as soil moisture and texture, temperature and aeration may affect the rate of SOM degradation. Although SOM needs to breakdown slowly, some farming practices can lead to its undesired rapid loss. Frequent cultivation also can adversely stimulate soil microorganisms by providing more oxygen. For this and other reasons that help reduce erosion, cultivation should be minimized. It is also suggested that growing the same crop year after year will lead to reductions in organic matter, but this is also strongly influenced by farming methods.

Conclusion

Australian farmers and land managers have long been recognised for their resilience and adaptability. Focussing these characteristics on the wide adoption of regenerative approaches to landscape management will support sustainable production and address degradation of the Australian landscape. By holistically managing our soil, water, vegetation, biodiversity and animal systems through improved knowledge and a capacity to mimic, as far as possible, Australia's highly effective natural processes, the natural and agricultural landscape can be regenerated and enjoy sustainable, healthy, profitable farming.

As stated by the *Soils for Life* organisation, the Australian population in general, and particularly those concerned with the landscape, must become "landscape literate". Change can start from the ground up - in the paddock - and hopefully bring about a paradigm shift in thinking by research institutions, rural communities, funding agencies and governments to support regenerative landscape management practices across the country.

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