Building soil carbon with Yearlong Green Farming

Dr Christine Jones, Founder of Carbon For Life Inc. www.amazingcarbon.com

The capacity for appropriately managed soils to sequester atmospheric carbon is enormous. The world's soils hold around three times as much carbon as the atmosphere and over four times as much carbon as the vegetation. **Soil represents the largest carbon sink over which we have control.**

When atmospheric carbon is sequestered in topsoil as organic carbon, it brings with it a wealth of environmental, productivity and quality of life benefits. An understanding of the 'carbon cycle' and the role of carbon in soils, is essential to our understanding of life on earth.

Building soil carbon requires green plants and soil microbes.

There are 4 steps to 'turning air into soil'

i) Photosynthesis
ii) Resynthesis
iii) Exudation
iv) Humification

Photosynthesis is a two-step endothermic reaction (ie a **cooling process**) which takes place in the chloroplasts of green leaves. Incoming light energy (sunlight) is captured and stored as biochemical energy in the form of a simple sugar - glucose ($C_6H_{12}O_6$), using carbon dioxide (CO_2) from the air and water (H_2O) from the soil. Oxygen is released to the atmosphere.

Photosynthesis requires 15 MJ of sunlight energy for every kilogram of glucose produced. If the same 15 MJ of incoming light energy makes contact with a bare surface, such as bare ground, it is reflected, absorbed or radiated - as **heat**, usually accompanied by moisture. The respective area of the earth's surface covered by either actively growing crops and pastures, or bare ground, has a significant effect on global climate.

Resynthesis: Through a myriad of chemical reactions, the glucose formed during photosynthesis is resynthesised to a wide variety of carbon compounds, including carbohydrates, proteins, organic acids, waxes and oils. Carbon atoms can link together to form long chains, branched chains and rings, to which other elements, such as hydrogen and oxygen, can join.

The energy captured during photosynthesis and stored in carbon compounds serves as 'fuel' for life on earth. Carbohydrates such as cellulose provide energy for grazing animals, the starch in grains provides energy for livestock and people. The carbon stored in previous eras as 'fossil fuels' (hydrocarbons) such as coal, oil and gas provides energy for vehicles, machinery and industry.

Exudation: Around 30-40% of the carbon fixed by grass plants during photosynthesis is exuded into soil to form a microbial

Figure 1. Root volume, rhizosphere surface area, exudation of carbon, microbial activity, humification and soil building are highly correlated with the perenniality and vigour of groundcover plants

bridge (to feed the microbes that enhance the availability of essential plant nutrients). In this way, actively growing crops and pastures provide 'fuel' for the soil engine.

Carbon compounds are essential to the creation of topsoil from the structureless, lifeless mineral soil produced by the weathering of rocks.

Organic carbon additions are governed by the volume of plant roots per unit of soil and their rate of growth. The more active green leaves there are, the more roots there are, the more carbon is added. It's as simple as that (Figure 1). The breakdown of fibrous roots pruned into soil through rest-rotation grazing is also an important source of carbon in soils.

Humification: Adding organic carbon to soil is one thing, keeping it there is another. Organic carbon moves between various 'pools' in the soil, some of which are short lived while others may persist for thousands of years. Carbon additions need to be combined with land management practices that foster the conversion of relatively transient forms of organic carbon to more stable complexes within the soil.

In the humification process, soil microbes resynthesise and polymerise labile carbon (exuded from plant roots) into high molecular weight stable humic substances. Humus, a gel-like substance that forms an integral component of the soil matrix, is the best known of the stable organic fractions.

Humification cannot proceed unless there is a continuous supply of 'fuel' for soil microbes. If humification does not occur, the carbon exuded from plant roots (or added to soil as plant residues or manure) simply oxidises and recycles back to the atmosphere as carbon dioxide.

Continued

Humic substances have significance beyond the relatively long-term sequestration of atmospheric carbon. They are extremely important in pH buffering, inactivation of pesticides and other pollutants, improved plant nutrition and increased soil-water-holding capacity. By chelating salts, humic substances can also effectively ameliorate the symptoms of dryland salinity. Increasing the rate of humification has highly significant effects on the health and productivity of agricultural land.

Importance of soil fungi

Most perennial grasses are excellent hosts for mycorrhizal fungi, with up to 100 metres of microscopic fungi forming per gram of soil under healthy grassland. Glomalin is a glycoprotein (contains both protein and carbohydrate) produced by arbuscular mycorrhizal fungi living on plant roots. Glomalin can persist for several decades and may account for one third of the stable organic carbon stored in agricultural soils.

Mycorrhizal fungi and glomalin production are inhibited by bare soil, intensive tillage, the application of phosphorus fertiliser and the presence of plants from the Brassica family such as canola, which do not form mycorrhizal associations.

Maintaining soil structure

'Aggregation' is part of the humification and soil carbon building process and is essential for maintaining soil structure. Glues and gums from fungal hyphae in the rhizosphere enable the formation of peds or lumps (which can be seen with the naked eye, often attached to plant roots). The presence of these aggregates creates macropores (spaces between the aggregates) which markedly improve the infiltration of water. After rain less water sits on the soil surface and waterlogging is reduced. As structure continues to improve, smaller and smaller aggregates are formed, along with soil mesopores and micropores, dramatically improving soil function, aeration, levels of biological activity and resilience.

Soil structure is not permanent. Aggregates made from microbial substances are continually breaking down and rebuilding. An ongoing supply of energy in the form of carbon from actively growing plant roots will maintain soil structure. If soils are left without green groundcover for long periods they can become compacted, blow or wash away.

Under conventional cropping or set-stocked annual pastures, the stimulatory exudates produced by short-lived species are negated by bare earth at other times of the year. The result is a decline in levels of soil carbon, soil structure and soil function.

Soil building requires green plants and soil cover for as much of the year as possible. In seasonal rainfall environments, a mix of perennial groundcover species enables response to rain at any time. In grazing enterprises, rest-rotation grazing is absolutely essential. For broadacre cropping, the presence of out-of-season groundcover ensures stability, long term productivity and soil building rather than soil destruction.

Any farming practice that improves soil structure is building soil carbon.

Water, energy, life, nutrients and profit will increase on-farm as soil organic carbon levels rise. The alternative is evaporation of water, energy, life, nutrients and profit if carbon is mismanaged and goes into the air.

Yearlong Green Farming (YGF) is any practice turning bare soil into soil covered with green plants. YGF increases quality, quantity and perenniality of green groundcover in broadacre cropping, horticultural, forestry and grazing enterprises.

Many benefits of Pasture Cropping, for example, can be attributed to having perennial grasses and cereals together side by side in space and time. Ongoing carbon additions from the perennial grass component evolve into highly stable forms of soil carbon while the short-term, high sugar forms of carbon exuded by the cereal crop roots stimulate microbial activity.

As a bonus, regenerative farming practices such as Pasture Cropping result in the production of food much higher in vitamin and mineral content and lower in herbicide and pesticide residues than conventionally produced foods.

Rewarding farmers for Yearlong Green Farming practices that build new topsoil and raise levels of organic carbon would have a significant impact on the vitality and productivity of Australia's rural industries. YGF would also reduce evaporation and heat radiation from bare soil surfaces, reduce the incidence of dryland salinity and counteract soil acidity.

Under **regenerative** regimes, soil carbon and soil life are restored, conferring multiple ecological and production benefits in terms of nutrient cycling, soil water storage, soil structural integrity and disease suppression. Benefits extend well beyond the paddock gate. Improved soil and water quality are the 'key' to catchment health, while YGF represents the most potent mechanism available for mitigating climate change.

It's about turning carbon loss into carbon gain.

Getting started in lifeless, compacted soils where the soil engine has shut down is the hard part. The longer we delay, the more difficult it will be to re-sequester soil carbon and re-balance the greenhouse equation.