

Carbon that counts

Christine Jones PhD

Failing a cataclysmic collision with an asteroid or a volcanic explosion of earth-shattering proportions, the thin layer of weathered rock we call soil will have to feed 50% more people before this planet gets much older. The problem has not gone unnoticed. Learned men and women have gathered, books have been written and conferences convened. What has been discussed? How to build new topsoil? No. Everything but.

The collective knowledge of the human species on almost every subject from sub-atomic particles to distant galaxies is extraordinary, yet we know so little about soil. Is it too common, this world beneath our feet? This stuff of life that sustains us?

Failure to acknowledge/ observe/ measure/ learn how to rapidly build fertile topsoil may emerge as one of the greatest oversights of modern civilisation. Routine assessments of agricultural soils rarely extend beyond the top 10 to 15 centimetres and are generally limited to determining the status of a small number of elements, notably phosphorus (P) and nitrogen (N). Over-emphasis on these nutrients has masked the myriad of microbial interactions that would normally take place in soil; interactions that are necessary for carbon sequestration, precursor to the formation of fertile topsoil.



Fig. 1. In this paired site comparison, parent material, slope, aspect, rainfall and farming enterprise are the same. Levels of soil carbon were originally the same

LHS: soil profile from a paddock that has not received superphosphate for over 30 years. Groundcover has been actively managed (cropped and grazed) to enhance photosynthetic capacity.

RHS: soil profile from a neighbouring paddock (10 metres through the fence) that has received regular applications of P and is set-stocked.

Due to increased levels of soil carbon and the accompanying increases in soil fertility, the **LHS** paddock now carries **twice** the stock of the **RHS** paddock.

Land management and soil carbon

The soil profiles illustrated in Fig. 1 are from neighbouring paddocks where slope, aspect, parent material, rainfall and farm enterprises are the same. Until relatively recently, the soils were also, to all intents and purposes, the same. They now differ due to the activation of the sequestration pathway in one of the soils, as a result of changes to land management.

The RHS soil profile has formed under conventional grazing and 'standard practice' fertiliser management. The LHS profile demonstrates how 50 centimetres of well-structured, fertile topsoil can develop in 10 years when superphosphate is not applied and plants are managed to maximise their photosynthetic potential. Over the last 10 years this soil has sequestered 168 tonnes of CO₂ per hectare, with the sequestration rate in the last two years (2008 - 2010) being 33 tonnes of CO₂ per hectare per year.

Levels of both total and available plant nutrients, minerals and trace elements have dramatically improved in the LHS soil, due to solubilisation of the mineral fraction by microbes energized by increased levels of liquid carbon. In this positive feedback loop, sequestration enhances mineralisation which in turn enhances humification.

As a result, the rate of polymerisation has also increased, resulting in 78% of the newly sequestered carbon being non-labile. The stable, high-molecular weight humic substances formed via this sequestration pathway cannot 'disappear in a drought'. Indeed, the new humus was formed against the back-drop of 13 years of below-average rainfall in eastern Australia.

It is important to note that the rapid improvement to soil fertility and soil function recorded here would NOT have occurred without the disturbance regimes associated with regenerative forms of grazing and cropping.

Most conventional cropping and grazing practices result in losses of soil carbon. The old maxim of 'add fertiliser' - and when that no longer works, add more - results in losses in biodiversity, losses in stable soil carbon at depth, reduced mineral levels in plants and animals and an increased incidence of metabolic disease. This will no longer do.

Even in New Zealand, a country blessed with abundant fertile topsoil, carbon losses are occurring at depth due to poor agricultural practices. These losses are the result of inhibition of the sequestration pathway. Alternative management practices have to date been either dismissed or ignored by establishment science.

Not just any carbon - and not just anywhere

The surface increment, 0-10cm, generally contains the highest levels of labile carbon, indicative of rapid turnover. This 'active' carbon is important to landscape function and the health of the soil food-web. But the surface increment is not where one would be looking to safely 'store' atmospheric CO₂. The deeper that carbon is sequestered, the better.

The level of non-labile soil carbon (ie the humic fraction) in the LHS profile has doubled in the 10-20cm increment, tripled in the 20-30cm increment and quadrupled in the 30-40cm increment. Over time, it is anticipated that the most rapid sequestration of stable soil carbon will be in the 40-50cm increment, then later still, in the 50-60cm increment. That is, fertile, carbon-rich topsoil will continue to build downwards into the subsoil.

Carbon sequestered below 30cm indicates good root penetration and high levels of microbial activity. Deeply sequestered carbon alleviates subsoil constraints, enhances landscape hydrology and improves mineral density in plants, animals and people.

The Kyoto Protocol, which relates only to carbon sequestered in the 0-30cm increment, completely overlooks this 'sequestration of significance' in the 30-60cm portion of the soil profile.

Making the world a better place

Property owner, Colin Seis, has no wish to revert to former management practices, as he can now carry twice the number of stock at a fraction of the cost. Nevertheless, if the land management were to change for some unforeseeable reason, the increased levels of humus (non-labile carbon) now present in his soil would remain for several hundred years, which is considerably longer than the average lifespan of carbon in trees.

In addition to reducing levels of atmospheric carbon dioxide over extremely long time periods (centuries), the activation of the sequestration pathway results in the release of plant nutrients from the theoretically insoluble mineral fraction, which comprises by far the largest proportion (96-98%) of the soil mass. This improves the health of pastures, crops, livestock and the people consuming agricultural produce. Everyone benefits when food is more nourishing. When the sequestration pathway has been activated, it is possible to feed more people from less land.

The levels of acid-extractable minerals in the LHS soil profile are higher than those on the RHS soil in the following proportions, calcium 277%, magnesium 138%, potassium 146%, sulphur 157%, phosphorus 151%, zinc 186%, iron 122%, copper 202%, boron 156%, molybdenum 151%, cobalt 179% and selenium 117%. Levels of inorganic plant nutrients have increased to a similar extent.

The formation of fertile topsoil can be breathtakingly rapid once the biological dots have been joined and the sequestration/ mineralization/ humification pathway has been activated. The positive feedback loops render the liquid carbon pathway somewhat akin to perpetual motion. You can almost see new topsoil forming before your eyes. The sun's energy, captured in photosynthesis and channelled from above-ground to below-ground as liquid carbon, fuels the microbes that solubilise the mineral fraction. A portion of the newly released minerals enable rapid humification in deep layers of soil, while the remaining minerals are returned to plant leaves, facilitating an elevated rate of photosynthesis and increased levels of production of liquid carbon, that can in turn be channelled to soil, enabling the dissolution of even more minerals.

Where do the 'new' minerals come from?

A standard soil test provides very little information about the bulk soil and the minerals potentially available to plants. Most lab reports list 'plant-available' nutrients (that is, nutrients not requiring microbial intermediaries for plant access) and if requested, acid-extractable minerals (misleadingly quoted as 'totals').

With respect to phosphorus, for example, the 'plant-available' levels are usually estimated using an Olsen, Colwell, Bray 1, Bray 2, Mehlich 1, Mehlich 3 or Morgan P test. These tests provide information on the relatively small pools of inorganic soil P. Where a figure for Total P is provided, it refers only to the quantity of P that is acid-extractable, not the actual 'total' amount of P in the soil.

Other techniques, such as x-ray fluorescence (XRF) are required to determine the composition of the insoluble, acid-resistant mineral fraction, which comprises 96-98% of the soil mass and contains far more minerals than are shown in a standard soil test.

Indeed, the top one metre of soil contains thousands of tonnes of minerals per hectare. Specific functional groups of soil microbes have access to this mineral fraction, while others are able to fix atmospheric N, provided they receive liquid carbon from plants.

The newly accessed minerals, particularly iron and aluminium, plus the newly fixed N, enable rapid humification of labile carbon. However, the liquid carbon needed to drive the process will not be forthcoming if high analysis N and/or P fertilisers inhibit the formation of a plant-microbe bridge.

The 'classic' models for soil carbon dynamics, based on data collected from set-stocked conventionally fertilised pastures and/or soil beneath annual crops, where the plant-microbe bridge is dysfunctional, fail to include nutrient acquisition from the bulk mineral fraction and hence cannot explain rapid topsoil formation at depth.

The puzzle is that establishment science clings to these out-dated models, inferring real-life data to be inconsequential. Measurements made outside of institutionalised science are branded 'anecdotal' and largely ignored.

When pastures (including those grown in association with crops) are managed to utilise nature's free gifts - sunlight, air and soil microbes - to rapidly form new, fertile, carbon-rich topsoil, the process is of immense benefit to farmers, rural communities and the nation.

Those who persist in maintaining that soil carbon comes at a 'cost' and/or disappears during a drought and/or requires applications of expensive fertiliser and/or necessitates forgone production - had better 'please explain'. The on-farm reality is that when the sequestration pathway for non-labile carbon has been activated, the opposite is true.

How much longer will the farming community have to endure the myths, misconceptions and misleading models put forward by the people currently employed to solve the problem of declining soil carbon, dwindling soil fertility and losses in soil function?

Will government show some initiative, seek the truth and act on it?

For further information see "The Story of Soil. Part I: sequestration, mineralisation and humification"
www.amazingcarbon.com

Here's the data

1990-2010: 168.5 tonnes CO₂ sequestered per hectare

2008-2010: Sequestration rate 33 tonnes CO₂ per hectare per year

Permanence: 78% of the newly sequestered carbon is in the non-labile (humic) fraction of the soil

Location: The greatest increases in soil carbon have occurred at depth, overcoming subsoil constraints. Non-labile soil carbon has doubled in the 10-20cm increment, tripled in the 20-30cm increment and quadrupled in the 30-40cm increment.

Minerals: The following increases in soil minerals have occurred – calcium 277%, magnesium 138%, potassium 146%, sulphur 157%, phosphorus 151%, zinc 186%, iron 122%, copper 202%, boron 156%, molybdenum 151%, cobalt 179% and selenium 117%.

Cash benefit: At a carbon price of \$20 per tonne, and assuming payment for non-labile (permanent) carbon only, the value of 33 tCO₂/ha/yr would be \$660 x 78% = \$515/ha/yr. A price on carbon would provide worthwhile incentive for progressive farmers to rebuild our precious agricultural soils.