Carbon Farming Handbook

2012

An Introduction to Soil Carbon,
Land Management and Climate Change

Carbon Farmers of Australia

The Carbon Farming Handbook

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(612)+ 6374 0329
www.carbonfarmersofaustralia.com.au

Welcome

This Handbook is for anyone who wants to start to understand Carbon Farming and the contribution farmers can make to the health of farm landscapes, rural economies and to our response to the challenge of climate change. With the passing of the Carbon Farming Initiative into law, farmers can now be rewarded for changing the way that they manage the land and their animals. Carbon Farming is not new. It has been known as Sustainable Farming, Natural Farming, Holistic Management and Biological Farming, among many others. Any farming method that reduces emissions of greenhouse gases or increases their storage in the landscape can be called Carbon Farming. This Handbook introduces many of them and provides a method of building a carbon farm plan that integrates them for maximum results.

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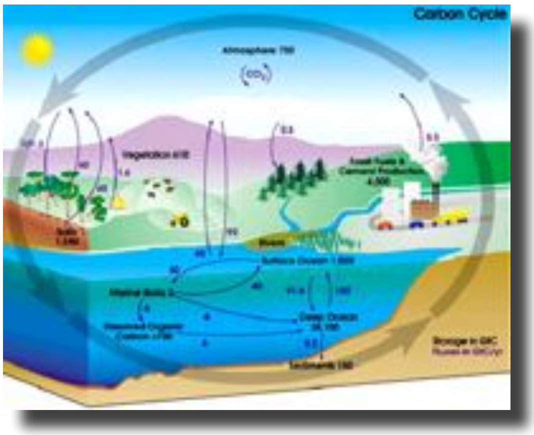
Carbon Farming Handbook

What is Soil Carbon?

Soil Carbon is one of the many resting places of Carbon as it cycles throughout the biosphere (the liveable area on the planet). Carbon is the basic chemical building block of all life on Earth. It also resides in mineral form in rock formations and in fossil fuels, such as coal and oil, as well as in the ocean. The amount of Carbon on Earth is fixed. So the many processes of Nature that use it need to access a supply of it and have somewhere to let it go. The result is a cycle as Carbon moves between the oceans, rocks, soil, and atmosphere. There are 38,000 Gigatonnes (Gt) of carbon stored in the oceans, 2500 Gt/C in soil, 750gt/C in the atmosphere, and 650 Gt/C in forests, grasslands, and other vegetation.[1] (The "Greenhouse" effect is caused by the cycle getting out of balance, resulting in the atmosphere housing more on a rolling basis than it was designed to hold in order to manage stable weather patterns.)



Photosynthesis is a process that cycles Carbon out of the air and into plants, to be eaten by animals and humans as well as being deposited in soils. Photosynthesis is the only process that can take CO2 out of the atmosphere. It separates the C atom from the O atoms, releasing the Oxygen and incorporates the C in the plant, or transfers it to the soil where it becomes humus or other forms of Carbon. Some of it is released into the air if plants die and oxidize or dry out, or rot, releasing C in the form of methane. Soil Carbon takes two main forms: 1. Decomposed bodies of microbes such as bacteria, fungus, nematodes and root systems that die when plants are grazed as well as other decomposed plant residues. These forms of Carbon can be cycled quickly, within weeks. This is called "Labile" carbon. 2. The Carbon that is incorporated into the soil itself, such as humus. In these forms it can remain stable for thousands of years.

Total Organic Carbon is the amount of C stored in the soil. It can be measured very accurately. While soil carbon is subject to "flux" – different amounts can be measured according to time of day, time of year, and weather conditions - averaging techniques make assessing the amount of increase or decrease in soil C percentage possible.[2]

[1] Lal, R., "Soil Carbon Sequestration in Latin America", in Carbon Sequestration in Soils of Latin America, Haworth, 2006

[2] Kimble, B, "Advances in Models to Measure Soil Carbon", in Carbon Sequestration in Sils of Latin America, Haworth, 2006

An Introduction to Carbon Farming

Carbon Farming is a new way to describe a collection of techniques which can increase soil organic carbon in agricultural land. Land management practices that encourage healthy, growing soil microbial communities and, in so doing, create soil organic carbon and strengthen the natural resource base, include the following:

• **100% groundcover** 100% of the time - This is a Carbon Farmer's goal. Soil covered by plants cannot be blown or washed away. It is cooler and more attractive to microbes than if it was exposed to the sun. Therefore overgrazing, (or "flogging the land", in Australian parlance) and burning grasses and stubble and ploughing are anti-carbon actions. In fact, they release tonnes of carbon into the atmosphere. These practices, along with clearing native vegetation, have put Agriculture officially in 2nd place, behind coal-burning power stations, as the biggest source of Australia's Greenhouse Gas emissions.

• **Grazing management** – Stock are concentrated in small paddocks for short periods (days) so that they graze evenly and at the same time till the soil with their hooves, stomping old grass and manure into it. The plants are then left to grow a full head of foliage so that their roots go down as far as possible into the soil. When they are grazed, the roots die back upwards in proportion to how much of the foliage was eaten. Overgrazing can cause the roots to shrink so short they struggle to get started again. So short grazing periods and long periods of rest are best.

• **No till cropping** – Ploughing disturbs the microbes and dries out the soil. It also releases tonnes of CO2 per hectare. No till techniques sow the seed in the top soil without tearing off the existing foliage or applying herbicides which are also bad for microbes. There are several no till techniques, including "Pasture Cropping" and "Advanced Sowing". The one direct drills the seed into pasture while the other slices a line through the pasture and inserts theseed. The crop grows up above the pasture and can be harvested or grazed. The pasture usually thickens and grows more vigorously after such treatment.

• **Mulching** – This takes two forms: 1. Covering bare earth with hay or dead vegetation. This protects the soil from the sun, cools it, and attracts soil-producing microbes. It also holds water where it can be used instead of letting it run off immediately. 2. Cutting down and dessicating tall, dead plants and thistles to form a layer of litter on the soil and allow the sun to penetrate and foster plant growth. Gardeners know the value of mulching.

• **Water management systems** – Water is essential to the carbon growing process. Several systems have emerged for maximising us of water that falls on a farm. Two names are prominent: Natural Sequence Farming (NSF) and Yeoman's Keyline System. NSF slows the flow of water through the landscape by returning eroded gulleys and creeks to swampy meadows and chains of ponds that they were when white settlers arrived. The water stays long enough to make more grass and plants grow, rather than rushing down widening gullies carrying the topsoil away. NSF is based on the natural topography of the land. So is Keyline Planning. It uses the shape of the land to determine the layout and position of farm dams, irrigation areas, roads, fences, farm buildings and tree lines. Both methods increase soil fertility and carbon.

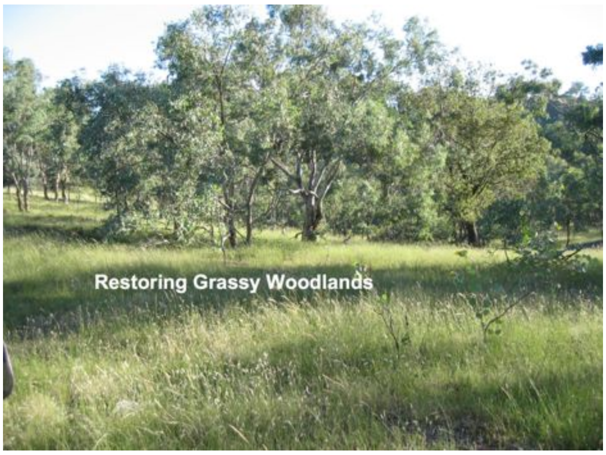
• **Biodynamics** – This is a method of treating soil, based on the theories of mystic and theorist Rudolf Steiner. He postulated that vital forces or energies flowed throughout the universe and that these can be harnessed to increase plant growth. Biodynamics adopts a homeopathic approach to preparing natural fertiliser and times activities to align with cycles of the moon and the stars. Many ordinary, sober farmers report great results with biodynamic preparations

• **Biological Farming** – This is the umbrella term for the use of natural compounds to stimulate biological activity in the soil. These compounds range from compost teas (concocted

after an analysis of the soil for deficiencies), worm juice (active enzymes created from worm castings), Biosolids (human effluent which needs to be plowed into the soil for hygene and odour reasons (not a favourite of carbon farmers), Nitrohumus (treated human effluent, needs no ploughing), Probiotics (beneficial microbes brewed for a long time in a food source medium), etc.

• **Composting** - This largely involves breaking down manure into a rich humus ready to spread on the fields. There is also a growing movement for recycling green wastes from cities for use on agricultural lands.

• **Trees** – Trees scattered across grasslands ("Grassy woodlands") provide shelter for stock and wildlife



and also have the effect of causing the soil adjacent to be richer in carbon. They can also assist in water management. And they help lift yields and productivity in both livestock and crops, with increases of between 20% and 40%.) [3]

These categories are broad. There are many variants and styles that purport to be different in essentials, but often the differences are of emphasis.

Biochar?

Biochar is black carbon produced by a process called Pyrolysis which involves low-temperature burning of biomass without oxygen. This black carbon remains relatively inert and it has twice as much carbon content as ordinary biomass. It is promoted vigorously by professors and scientists as a superior method of sequestration to soil carbon because of its stability. Biochar is also a powerful soil amendment, capable of boosting production of crops. Biochar production has as a side effect the production of a fuel gas. The attractiveness of the concept is made all the more potent by the legend of Terra Preta, the living soils of the Amazon, part of the Spanish myth of Eldorado.

Mystery shrouds the biochar solution, however, because it has failed to gain the widespread adoption expected from a solution that has had as much publicity and promotion by significant individuals such as Professor Johannes Lehmann and Dr Tim Flannery. The issue of cost has been cited as a barrier to deployment, although one company in Australia claims it can supply at $20/tonne. The scientists working on refining the product have advised application rates of between 10-20tonne/hectare, which almost rules it out as a broadacre product.

Black Carbon

Charcoal (or black carbon), which forms in bushfires, makes up a significant proportion of the total soil carbon, according to Dr Evelyn Krull, head of the Aquatic Biogeochemistry and Ecology research group at CSIRO Land and Water.[4] This means the models

used to predict the behaviour of soil carbon under Climate Change conditions will need to be adjusted. Dr Krull's team analysed soil samples stored in archives from hundreds of sites across Australia and according to their analyses,

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[3] Gillespie, R. (2000) Economic Values of Native Vegetation, Background Paper Number 4, Native Vegetation Advisory Council, Sydney. Lockwood, M., Walpole, S.C. and Miles, C.A. (2000), Economics of remnant native vegetation conservation on private property, LWRRDC Research Report 2/00, LWWRDC, Canberra. Miles, C.A., Lockwood, M. Walpole, S., Buckley, E.(1998) Assessment of the on-farm economic values of remnant native vegetation. Johnstone Centre Report No. 107. Johnstone Centre, Albury. Walpole, S.C. (1999), Assessment of the economic and ecological impacts of remnant vegetation on pasture productivity, Pacific Conservation Biology, 5: 28-35.

[4] http://www.aussmc.org/soil_carbon.php

charcoal (or black carbon), which forms in wildfires, makes up a significant proportion of the total soil carbon. "Our research from a large dataset of Australian soils has shown that charcoal makes up a significant portion of the soil organic carbon pool. Charcoal is highly stable and resides in the soil over much longer (decades to centuries, up to millennia) time periods compared with other soil carbon fractions. Current climate models do not take into account the proportion as well as the variability of charcoal in soils globally. Thus, their calculated response of CO2 release from soils is likely to be an over-estimate as it does not incorporate the charcoal. pool. Our research in other parts of the world has shown that charcoal is ubiquitous in soils and it is critical to adequately account for this proportion so that models that include the carbon cycle climate feedback can achieve reliable results."

By including realistic stocks of charcoal in their climate prediction models, the amount of carbon dioxide predicted to be released from two Australian savannah regions under a 3ºC warming scenario was 18.3% and 24.4% lower than previously calculated. As global warming continues, increaseing temperatures are expected to increase the decomposition of soil carbon, releasing more carbon dioxide.

Now the good news

U.S. scientists say higher temperatures created by global warming don't result in persistent elevated levels of decomposing organic matter. Current models of global climate change predict warmer conditions will increase the rate by which bacteria and other microbes decompose organic matter -- a scenario that releases even more carbon into the atmosphere. But while the rate of decomposition increases for a brief period, it does not persist. "What our finding suggests is that a positive feedback between warming and a loss of soil carbon to the atmosphere is likely to occur, but will be less than currently predicted," said Assistant Professor Mark Bradford, of the University of Georgia.

The research is reported in the online edition of the journal Ecology Letters.

Dr Rattan Lal on Soil C Trading

"Coming events are casting their shadow in this important and emerging field of immense significance to soil science, and the researchers must put their act together before the train departs the station.. While techniques of measuring concentration of C in soils, methodologically sampled and carefully prepared for laboratory analysis, are well known, the principal challenge to soil scientists lies in: (i) upscaling the point data to landscape, farm, watershed or a region ... (ii) evaluating changes in soil C with reference to a baseline for cultivated land unit comprising a large farming community, and (iii) verifying that the C thus sequestered is permanent ... Soil and tillage researchers must be pro-active in this important theme."

Carbon Farmers Slow Climate Change?

Scientists now believe that Carbon Farming can reduce CO_2 in the atmosphere fast enough to avoid the very worst consequences of Global Warming. [5] Some even claim we can reverse it.[6]

The major cause of CO_2 release from land management in farming is opening the soil to the air, by clearing native vegetation, by ploughing, by burning, and by over-grazing. Substituting other methods for these practices prevents CO_2 emissions. But these other methods are not only useful in cutting emissions. They can turn agricultural soil into a massive carbon sink, capable of sequestering millions of tonnes of carbon beneath the ground.

In its 2007 draft report, the Intergovernmental Panel on Climate Change's Chair Dr Rajendra Pachauri said: "Twenty-first century anthropogenic (human) carbon dioxide emissions will contribute to warming and sea level rise for more than a millennium, due to the time scales for removal of this gas." Britain's Chief Scientist Sir David King has said: "Even if humanity were to stop emitting carbon dioxide today, temperatures will keep rising and the impacts keep changing for 25 years." America's senior ozone hole scientist, Dr Susan Solomon, senior scientist of the of the Global Monitoring Division of the U.S. National Oceanic and Atmospheric Administration: "The carbon dioxide that's in our atmosphere today – even if we were to stop emitting it tomorrow – would live for many decades, centuries and beyond. A fraction of the carbon dioxide that we have put into the atmosphere today due to human activity would still be there in 1,000 years." The Australian Greenhouse Office, Department of the Environment and Heritage ("Climate Change Risk and Vulnerability", 2006) said: "Much of the climate change likely to be observed over the next few decades will be driven by the action of greenhouse gases already accumulated in the atmosphere."

The IPCC, NASA, and the Australian Greenhouse Office agree: there is already enough CO_2 in the atmosphere to push the globe through the 2°C increase that will cause climate chaos. The only way to remove it is Photosynthesis. Plants and Trees. No other popular solution can do it – clean coal, nuclear power, solar and wind power, these can only avoid future emissions. And Forests, even if we planted enough today, cannot reach critical mass in less than

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[5] Lal, Dr. Rattan, "Farming Carbon", Soil & Tillage Research, (6 (2007); "soil Science and the Carbon Civilization", SSSAJ Vol 71 No. 5 Sept-Oct 2007; "Soil Carbon Sequestration Impacts on Global Climate Change and Food Security", Science, Vol 304, 11 June, 2004. Dr Lal is President of the American Soil Science Society.

[6] Allan Yeomans, Priorty One: Together We Can Beat Global Warming, Biosphere Media, Arundel, 2007

15-20 years. The Stern Report said we have 10 years in which to act, and NASA agrees. The only solution is agricultural soils. They already have critical mass and can start sequestering carbon instantly on a large scale.

A slight increase in soil carbon across Australia's agricultural regions can sequester more than half our greenhouse gas emissions. A 0.1% increase in organic carbon across only 10% of Australia's agricultural lands would sequester 387 million tonnes CO_2. Australia's emissions are projected to reach 603 million tonnes annually over 2008–12. (Soil C in the top 20 cm of soil with a bulk density of 1.2 g/cm3 represents a 2.4 t/ha increase in soil OC which equates to 8.8 t/ha of CO_2 sequestered.* A pasture cropping/time controlled grazing combination in Central West NSW recorded increase in soil carbon from 2% to 4% over 10 years (0.2%C/yr)

* Dr Christine Jones, Aggregate or aggravate? Creating soil carbon, YLAD Living Soils Seminars: Eurongilly - 14 February, Young - 15 February 2006

ONWARDS!

Carbon Cocky Chooses Agrowdrill

Inaugural winner of the Carbon Cocky of the Year Award Michael Inwood of the Bathurst district chose a 2OR DF1000 Agrowplow Agrowdrill seed drill with 11 Agrowdisc V-Slice disc units because he is an innovator and knows that Agrowplow shares his passion for soils. Call the company whose name means sustainability on (02) 6845 1566.

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Changing The Way We Farm

Governments everywhere are trying to find a way to achieve ecologically sustainable natural resource use in a climate change environment. Soil carbon is a key performance indicator of ecological health. By focusing land managers attention on their soil carbon scores – via the incentive of carbon trading revenue – policy techniques to address the dual Climate Change problem that will face land managers with increasing severity: increasing temperature and reduced moisture. Governments are also seeking management systems for achieving sustainability measures for natural resources. As proven by the conflict and confrontation in the

The Benefits of Soil Carbon Credits

www.carboncoalition.com.au

makers responsible for Natural Resource Management would be harnessing the two primary drivers in farmer psychology: 1. The profit motive, and 2. Pride in selling what they grow. Governments trying to identify land and water use management practices that can act as a tool to tackle climate change need look no further than Carbon Farming Western Division of New South Wales over land clearing, a win-lose situation is always the outcome when Government seeks to impose its will on fiercely independent individuals who choose to live the life of struggle that we call agriculture. The soil carbon solution is a management system that manages through self interest and respect for the independence of the individual. Farmers would prefer to earn money from what they grow rather than accept "stewardship" payments which rely on the good-will of governments and which can be discontinued with changes in government. It is in the hands of policy makers in the carbon industry to make soil carbon credits tradable and unlock the greatest revolution in land management since the invention of the plough. Those who seek to force soil carbon into the same mould as other tradable commodities when it requires innovative thinking are denying us access to what could be the most significant technology solution to Climate Change within reach.

Carbon, The Element of Life

Carbon is the element that conveys life to the system. All living systems must have carbon; it is the energy storehouse for the system. Carbon is the governor of moisture. One part biocarbon holds four parts water. The biologically active carbon (humus) content of the soil determines its sustainability, efficiency, and productivity. The greater the amount of carbon, the greater the energy reserve. Carbon buffers the soil, improves soil tilth, and improves nutrient holding capacity."

- Arden Andersen, Science In Agriculture, Acres, 2000

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Soil Organic Matter

"Soil organic matter (SOM), of which 58% is carbon, is one of our most important national resources," says Rattan Lal, Professor of Soil Science and Director of the Carbon Management and Sequestration Center at The Ohio State University.

"SOM is a minor comp-onent of the soil (1-3%), but plays a very important role in biological prod-uctivity and eco-system functions."

"Soil organic matter" includes all the organic substances in or on the soil.

• Living organisms: Bacteria, fungi, nematodes, protozoa, earthworms, arthropods, and living roots.

• Dead plant material; organic material; detritus; surface residue: All these terms refer to plant, animal, or other organic substances that have recently been added to the soil and have only begun to show signs of decay.

• Active fraction organic matter: Organic matter that can be used as food by microorganisms. The active fraction changes faster in response to management changes than total organic matter.

• Labile organic matter: Organic matter that is easily decomposed.

• Root exudates: Soluble sugars, amino acids and other compounds secreted by roots.

• Particulate organic matter (POM) or Light fraction (LF) organic matter: POM and LF represent the active fraction of organic matter which is more difficult to define. POM or LF is larger and lighter than other types of soil organic matter, so they can be separated from soil by using a sieve or a centrifuge.

•Lignin: Hard-to-degrade comp-ounds that are part of the fibers of older plants. Fungi can consume the carbon ring structures in lignin as food.

• Recalcitrant organic matter: Organic matter such as humus or lignin that few organisms can decompose.

• Humus or humified organic matter: Complex organic compounds that remain after many organisms have used and transformed the original material.

Soil Organic Carbon

Soil carbon, or soil organic carbon (SOC) is carbon stored in soil. It is part of soil organic matter (SOM), alongside other elements like calcium, hydrogen, oxygen, and nitrogen. It is made up of decomposing plant and animal materials (and by-products of microbial activity).

SOM is reported in soil tests as the percentage of SOC in the soil sample. Scientists tell us that knowing the types of organic carbon in a sample can greatly impact soil productivity. "We have established that the amount of each organic carbon fraction varies significantly across soil types and some fractions can be altered by management practices," says Dr Jeff Baldock, CSIRO Land and Water.

Jeff says there are four biologically significant types or fractions of soil organic carbon:

*crop residues – plant residues less than 2 mm in the soil and on the surface

*particulate organic carbon – plant debris smaller than 2 mm but larger than 0.053 mm

*humus – decomposed materials less than 0.053 mm attached to soil minerals

*recalcitrant organic carbon – this is biologically stable, typically char.

Each fraction of soil carbon has different functions:

*crop residues - readily broken down to provide energy to soil biological processes

*particulate organic carbon - broken down relatively quickly but more slowly than crop residues - important for soil structure, energy for biological processes and provision of nutrients

*humus - plays a role in all key soil functions - particularly important in the provision of nutrients - majority of available soil nitrogen derived from soil organic matter comes from the humus fraction

*recalcitrant organic carbon - a product of burning carbon-rich materials - usually charcoal - decomposes very slowly and is unavailable for use by micro-organisms - many Australian soils have high levels of charcoal from thousands of years of burning.

The amount of each type of carbon in our soils varies significantly. Good soils can have organic carbon >10 per cent, while in many poorer soils or degraded soil carbon readings can be <1 per cent.

Management practices can also influence proportions of different fractions present. The fractions decompose at rates and contain quantities of nutrients that are different in every case. This affects the health and productivity of the soil.

Dr Baldock believes that it is difficult to build up soil carbon in Australia, given our climate: "Carbon levels build up where water, nutrients and sunlight are plentiful," he says.

"SOC is the most important indicator of soil quality and agronomic sustainability because of its impact on other physical, chemical and biological indicators of soil quality". [7]

Scientists have been traditionally pessimistic about soils with low SOC scores: SOM concentrations are often cited as major indicators of soil quality. However, scientists have reported that there are minimum or maximum threshold values of soil carbon, above or below which the beneficial effect of SOC is diminished. An upper threshold of SOC exists, they say, beyond which no further increases in productivity were achieved. For instance it has been estimated that the threshold value for most soils was at 2% SOC (equivalent to 3.4% SOM), below which most soils are prone to structural destabilisation and crop yields are reduced. No matter what type of soil, it appears that if SOC contents are below 1%, it may not be possible to obtain "potential yields".

SOC levels can also be too high, says Krull et al.: "… detrimental effects can occur if too much carbon is added to the soil… For example, too much carbon can result in surface crusting, increased detachment by raindrops and decreased hydraulic conductivity. One reason for structural breakdown is a high content of monovalent cations, which can occur if too much animal waste is added. Similarly, high additions of NH_4^+ fertiliser may accumulate and both high organic and N additions could cause not only environmental problems but would contribute to increased dispersive effects.

"As a rule of thumb, waste applications of over 100 t ha^{-1} are considered a possible hazard… Water-repellency is another possible consequence of too much organic matter

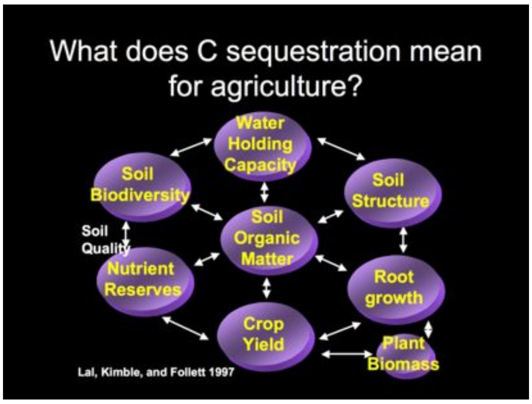
SOC results are usually expressed as % C by weight (i.e. g C per 100 g of soil). SOC results can be converted to soil organic matter (SOM) level by multiplying SOC value by a conversion factor of 1.72. This assumes that SOM present in soil, on average, is made up of 58 % carbon.

[7] Functions of Soil Organic Matter and the Effect on Soil Properties, Evelyn S. Krull,, Jan O. Skjemstad, Jeffrey A. Baldock, CSIRO Land & Water

Benefits of SOC

There are so many benefits that flow from increasing soil organic carbon that farmers should be satisfied with these and forget about selling their carbon, according to many non-farmers. The ‘co-benefits’ of SOC are many, as Professor Rattan Lal has recorded:

“The soil organic carbon pool is an important indicator of soil quality, and has numerous direct indirect impacts on it. For example, increase in SOC pool in degraded soils improves soil structure and tilth, reduces soil erosion, increases plant available water capacity, stores plant nutrients, provides energy for fauna, purifies water, denatures pollutants, increases soil biodiversity, improves crop/ biomass yields, moderates climate. It makes soil a living ecosystem. Indeed, it is a nation’s most precious resource.”[8]



In another place he argues that biodiversity is a major outcome of soil carbon sequestration: “There is a strong relationship of biodiversity with soil structure and its functions, soil fertility and tillage methods. Soil fauna and flora are key bioindicators of soil quality… Soil biodiversity plays an important role in sustainable farming and strongly impacts economics of production.”[9]

Lal believes the Ecosystem Services alone should make SOC a national priority, putting a value on it of more that US$200 a tonne. These services include: Air Quality, Water Quality, Productivity, Fewer Pollutants, Less Dust, Less Sediment, Drought and Disease Resistance,

and Mitigation of climate change.

Dr Lal believes the greatest challenge to soil science will be ensuring food security, especially in poorer nations.

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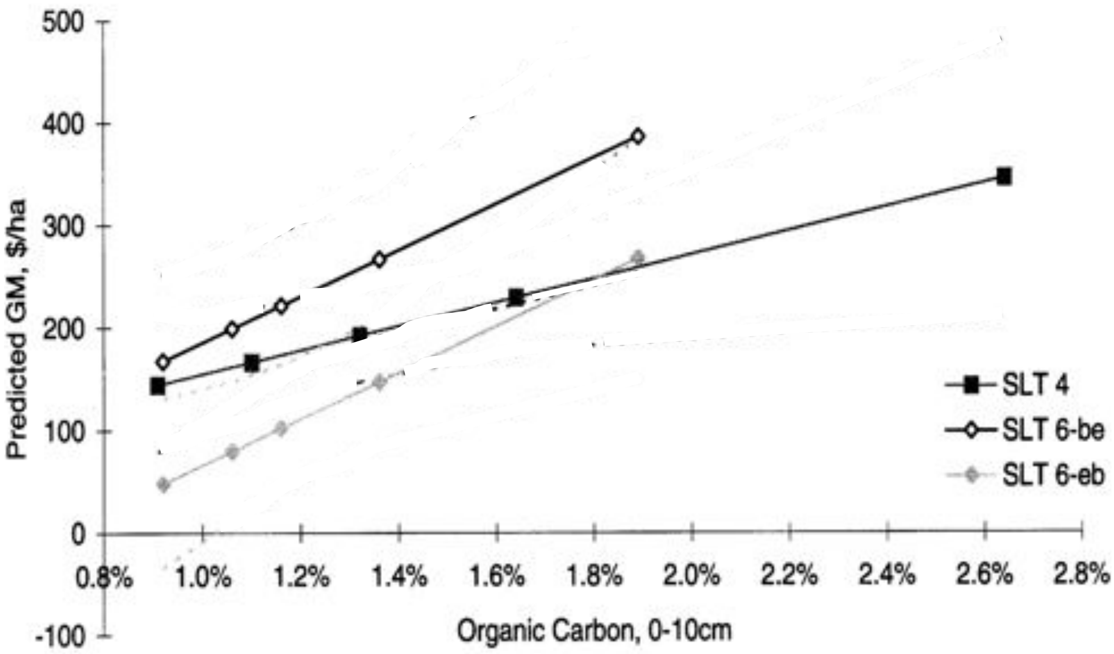
[8] Lal, Dr Rattan, “Farming carbon”, Soil & Tillage Research 96 (2007) 1–5

[9] Lal, Rattan, “Soil Science and the Carbon Civilization”, SSSAJ: Vol. 71 (5), September/October 2007

Dollar Value of Soil Organic Carbon



A CSIRO study using comprehensive soil data from Wagga predicted farm gross margins on specific soil types from their soil organic carbon content. Assigning a single dollar value is difficult, because the value changes with soil type, season & cropping practice. Source Ringrose-Voase et al (1997) figure 4, CSIRO Land &Water Tech Rep 17/97. From PUTTING A DOLLAR VALUE ON ORGANIC CARBON IN SOIL Pam Pittaway, Chrysalis Landscape Consultants
www.grubbclc.com.au

Dr Rattan Lal on Soil C Trading

"Soil C requires an interdisciplinary approach to manage it and commodify it through trading of C credits.""

"In cooperation with economists, soil scientists must develop a protocol to trade C credits. It will require development of routinely usable techniques to measure change in soil C pool at landscape level over a time span of 1 to 2 yr. The process of 'carbon farming' as a marketable commodity requires development of measurement, monitoring, and verification (MMV) techniques. The global C market has the potential to grow to US$1trillion by 2020 or before. Soil scientists must position themselves to tap into this growing market by making soil C a tradable commodity."

The Soil Carbon Solution

Soil Carbon is a powerful substance. It has many good effects when you start to grow it. These effects are all good reasons to buy soil carbon offsets. Every effect is a benefit that makes our "product" more attractive to a buyer than our competitor's product. (Eg. Forest offsets)

Why "Solution"?

Simply because a solution is much more than an offset. Soil Carbon is a solution to many problems: food security, water conservation, etc. In that 'etc.' there are a lot of positive messages that most people don't know about. The "Solutions" can be divided up into 4 groups: Agronomic, Economic, Evironmental, and Social.

Agronomic Solutions

Harnessing the full power of the soil microbial community
Greater availability of locked up N, P, K
Improved cation exchange capacity
Healthier, more resilient plants
Better water availability
Reduced reliance on herbicides, pesticides, fungicides
Less soil compaction/fewer passes/better soil friable
Drought buffer for hot and dry conditions

Economic Solutions

Lower input costs
Lower labour costs
Lower fuel costs
Lower break even

Environmental Solutions

Less erosion
Better soil structure
More vegetation
More biodiversity
Return of native species

Social Solutions

Assist with Climate Change
Help restore climate stability
Boost farm incomes
Boost farm family morale
Maintain rural communities
Support rural social infrastructure, eg. schools
Boost regional economies
Provide employment
Optimism

Soil Carbon is not a simple substance. It is the main product of the process where death and life meet. It governs the world's capacity to feed itself.

Can we capture carbon?

"There are a whole range of SOC levels in different soils. For instance, for the surface soils, SOC ranges from about 10% in the alpine soils to less than 0.5% in the desert soils," says Dr Yin Chan of the NSW Department of Primary Industry.[10] The amount of SOC stored in the soil profile can be considerable. For example, if there is 1% SOC over 30 cm soil depth, the amount of SOC stored over 1 hectare of land can weigh about 42 tonnes. Usually, the surface layer has the highest level of SOC which decreases with depth down the soil profile."[11]

"In Australia, it has been estimated that, in many areas, soil carbon levels have dropped by up to 50% compared to pre-agricultural periods… Therefore, soil carbon levels of agricultural soils are lower than corresponding soils under natural vegetation. This difference in SOC indicates the potential for soil carbon storage."

The losses of soil carbon are greatest in conventional ploughing and spraying out weeds and insects. Even changing to no-till techniques on its own is not enough to do more than stop the losses of CO2 and topsoil. Retaining stubble is another 'standing still' strategy – this time it is giving the microbes in the soil something to chew on while they wait for the next crop. In fact, Dr Peter Fisher (DPI VIC) was astounded when he found a 0.4%C increase over 10 years in a recently reported study.

There are four key factors that determine if and by how much a soil can sequester carbon:

- soil type
- rainfall
- temperature
- vegetation

But it is management practices that make the difference within those parameters. Management practices that reduce soil organic carbon include:

- fallowing
- cultivation/ploughing
- stubble burning
- stubble removal, and
- overgrazing.

Each results in bare earth. Soil that lies unprotected from sun, wind and rain is unlikely to provide a good home for the soil microbes that do all the work of providing nutrients for plants and manufacturing carbon in soil.

The Sun on Bare Earth:

- overheats the top 10cms where most of the activity takes place;
- dries the top soil to a hard crust.

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[10] Dr Chan is in the top 10 soil scientists for references to his scientific papers.

[11] *(Dr Yin Chan*, Increasing soil organic carbon of agricultural land, PRIMEFACT 735 JANUARY 2008 *Principal Research Scientist (Soils), Richmond)*

The Wind on Bare Earth:

- carries away tonnes of valuable top soil;
- dries out the top layer of soil, which discourages microbial life.

The Rain on Bare Earth: Rain drops on hardened crust can break up the structure of the top soil; Water running over soil which has no biomass above (leaves and stems) or below the soil (rootmass) will carry away tonnes of valuable topsoil, silting waterways and robbing the farm enterprise of its most important asset.

Management practices that increase soil organic carbon include:

Increasing inputs

- stubble retention
- composts
- manure
- other recycled organic materials
- green manure

Decreasing losses

- stubble retention
- cover cropping

'The long term trial results highlight the fact that by using the right management practices, we can turn a farm from C source to C sink'

- Dr Y.N. Chan

"We are part of the earth and it is part of us... What befalls the earth befalls all the sons of the earth" - *Chief Seattle, 1852*

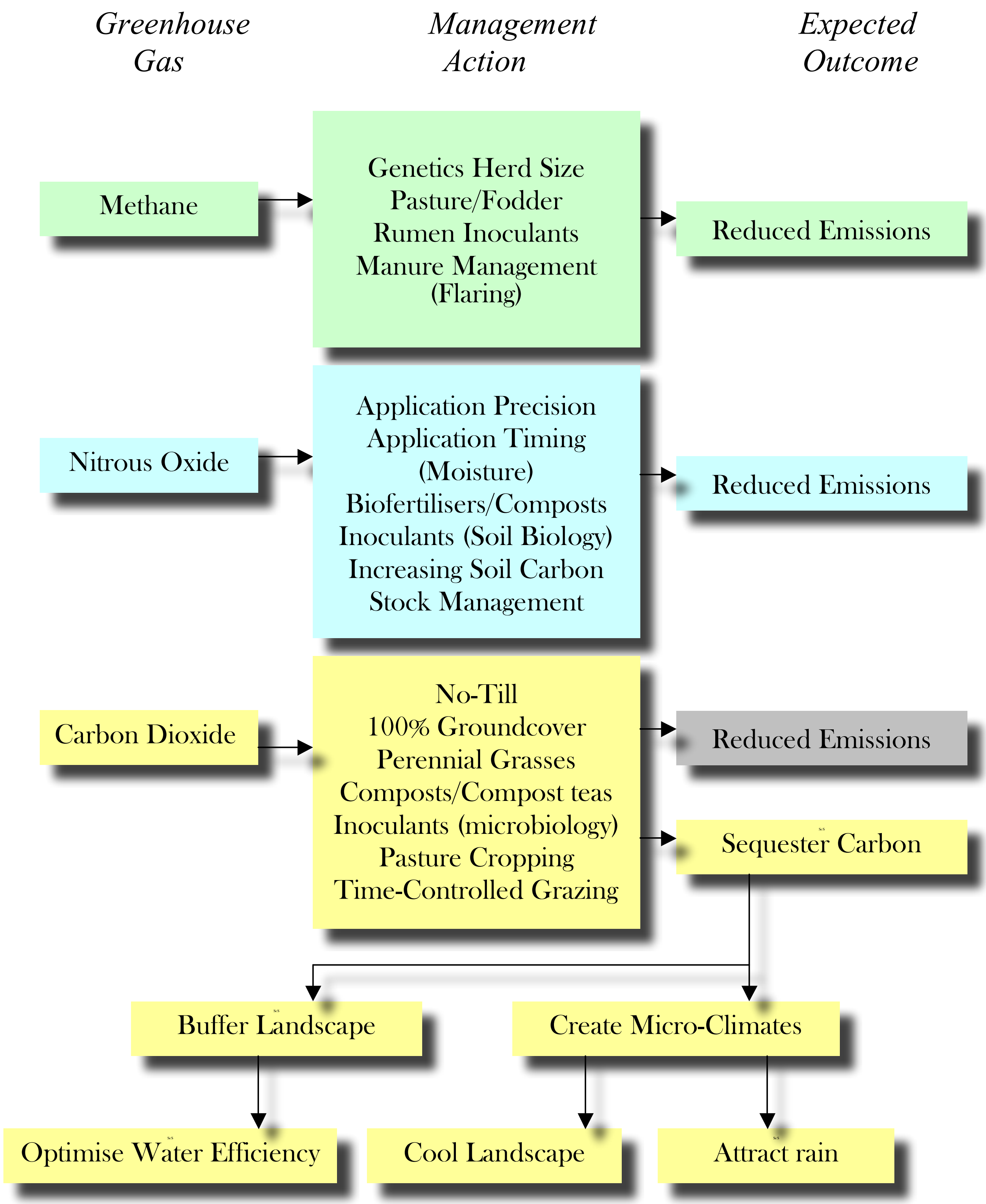
Carbon Farming Techniques

There are many techniques that increase soil carbon. None of them are superior to all others. We urge you to discover every alternative and experiment with those that suit your situation. What works in coastal regions may not work on the tablelands or out on the rangelands. Carbon Farmers of Australia are 'broad church' when it comes to accepting techniques for sequestering carbon in soils. The carbon score tells the tale. This list is not exhaustive and the brief introductions given here are very general and will require that you pursue further reading. Some further references are given at the end of each entry.

- Grazing Management
- ConservationTillage (incl. Pasture Cropping)
- Hydrological Planning (including Natural Sequence Farming)
- Biological Farming (incl. Organic Farming)
- Biodynamic Farming

These are considered the major umbrella categories. Missing from the mix are "Soil Treatments", including minerals such as PEV's Bentonite and paramagnetic rock dust from Boral or microbiological brews such as VRM's Probiotic inoculants and Elaine Ingham's compost teas, or treated human wastes such as Nitrohumus from Australian Native Landscapes and items such as biochar from Best Energies. These deserve a separate volume for their diversity.

Climate Change Agriculture
Adaptation Strategies



Grazing Management

Grazing Management is a term that covers a wide range of systems and techniques. They can be called Planned Grazing, or Grazing Management, Intensive Grazing Management, or Time-Controlled Grazing, or Rotational Grazing, or Holistic Management, or Grazing For Profit, etc…

They have many different names. But they have one thing in common: They involve regulating the time stock have access to pasture and increasing the time plants have free of being grazed. And they all seem to share the same objective (although they will have different degrees of success). The purpose of a grazing management system is to maximize fodder production by engaging the animals as suppliers of fertilizer and tilling services for the plant. The animals also help refresh and renew the plant's foliage by grazing it before it oxidizes (dies and dries out).

The approach is characterised by the division of a small number of large fields into a large number of small fields. By concentrating the animals on a relatively small area, the manager forces them to graze evenly.On the other hand, conventional set-stocking – a small group of animals are left for extended periods of time in large paddocks – lets them to graze preferentially (pick and chose) and leave other vegetation to run to seed.

By creating a large number of fields – we turned 8 paddocks into 24 in one project – you change the time frame for each piece of land. With more even grazing, and more the animals don't return to the paddock they are just leaving for up to 4 times as long as under the old set-stocking regime. This is joyful news for pasture plants because they can be given a long period (up to 150 days in good times,

up to a year in some systems) in which to recover.

The manager makes the call on when to make the move, based

on how much foliage the plants need to retain in order to recover quickly. The Managed Grazing enterprise avoids baring the soil by overgrazing. It gives the plant sufficient foliage to make a fast recovery. The faster the recovery, the more foliage is available to the system, the more secure the grazing enterprise. The Managed Grazier aims for, first and foremost, increasing the productivity of the soil.

The Carbon Grazier

The Carbon Grazier has a different foundation objective: Carbon. Grazing for Carbon is a specific management object-ive, not the side effect of something else. The focus for growing Soil Carbon is in the root system, underneath.

The Carbon is a by-product of the lifecycle of soil microbes. In their daily work of serving the needs of the roots (and being rewarded by being fed 'exudates' produced by the plant's roots), the billions of bacteria, fungi, nematodes, minute mites and earthworms process the carbon captured from the air by the plant's amazing skillset called "Photosynthesis". Using this magic technology, the plant absorbs the CO2, separates the O from the C, combines a couple of H atoms with the O atom and releases it as water vapour.

The plant then incorporates

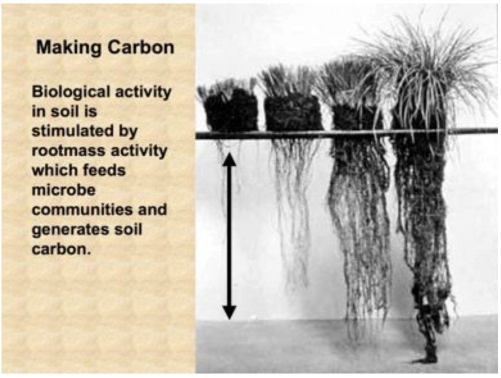
the carbon into its leaves (and into us if we eat the plant or any animal that ate the plant). Other Carbon atoms became part of the roots and fed the microbes living close to the root system. The billion of microbes consume the carbon and make it part of their bodies. It also forms part of the mysterious substance humus, the most stable form of soil carbon.

These microbial manufacturers of soil carbon must be managed to perform at their best. This guides the land manager who is no longer a grazier or even a grass farmer.

The manager is now a soil farmer and, beyond that, a soil microbe farmer. The microbes have a list of demands:

* Food – they need organic matter to feed them. So we return all dung and uneaten biomass to the soil by the action of the hooves of the animals.

*Temperature Control – microbes do not like direct sunlight on the soil because it gets too hot. So the land manager keeps all bare soil covered, either by mulch, litter or growing vegetation.



Root Action

One further process must be described because it is an important part of the dynamic of grazing management: the action of the roots systems of perennial plants. Perennials are superior pasture plants for Australian conditions for the following reasons:

Δ They have deep, water-seeking roots that can punch through tough soils to create water access channels for when the rains come.

Δ Many Australian native species have a food value equivalent to annual plants like clover.

Δ The perennial continues to provide food when the annual has given up and, in dying off, left the ground bare.

Δ Native species encourage the revival of ecological systems.

The 'pulsing' of the grazing takes the top off the plant. When that happens, the roots die proportionately up to the level determined by how 'hard' the graze was. The roots penetrate deeply while the foliage is growing and retreat when it is grazed or harvested. This pulsating action creates a feeding frenzy among the microbial communities – firstly on the exudates expressed by the roots, then on the detritus of the sloughed off dead roots. Carbon accumulates as a result.

Conservation Tillage

Traditional methods of producing crops usually involves regular ploughing of the soil (tilling) that disturbs the soil. Tilling can be used to remove weeds, mix in fertilizers, shape the soil into rows and furrows for irrigation, and prepare the soil for seeding. It also has negative impacts: like soil compression or compaction, loss of organic matter, soil disintegration, death of soil microbes, and soil erosion.

Continuous tillage destroys the soil resource base and has other adverse environmental effects, such as degrading the fertility of soils, air and water pollution, intensifying drought stress, and contributing to global warming by baring the soil and releasing CO2 and methane.

No-till is an effective way to protect soil. Crop residues or other organic matter are retained on the surface and sowing is done with minimal soil disturbance. This means soil structure and soil biota are conserved in their natural state. Variations of the conservation tillage involve some working of the soil while keeping soil compaction and carbon loss at a minimum. These variations include strip-till, in which small strips may be plowed to allow space for planting seeds. Strip-tillage should till no more than 1/4 of the field area. Strip-tillage is used in where the soil profile contains a hard pan that creates a barrier preventing plant roots from moving deeper to reach water and nutrients.

No-till has carbon sequestration potential through storage of soil organic matter. Cropland soils are ideal for use as a carbon sink, since it has been depleted of carbon in most areas. By reducing tillage, leaving crop residues to decompose, and growing winter cover crops, carbon loss can be slowed and eventually reversed.

Other benefits of no-till include increasing soil quality (soil function), protecting the soil from erosion, evaporation of water, and structural breakdown. Crop residues help water infiltrate the soil where it can be used. The crop residue also limits evaporation, conserving water for plants. Fewer tillage passes can prevent the compaction of soil. Less tillage reduces the need for contract labour and fuel and machinery costs. Less soil plowing means less airborne dust, which is a serious pollutant in some agricultural areas. No-till fields often have beneficial insects, a higher microbial content, and more soil organic material.

Disadvantages: Yields are often lower to start when making the transition. A combination of technique, equipment, pesticides, crop rotation, fertilization, and irrigation has to be found which is optimal for the conditions. In spring the soil can take longer to warm and dry, which may delay planting. And residue from the previous crops can harbour pathogens, leading to a higher level of disease.

No-till farming also needs special equipment, the combination of machinery has to be custom-tailored to the condition of the soil. However, today many types of no-till seeding equipment are readily available.

No-till farming changes weed varieties drastically. Faster growing weeds may no longer be a problem in the face of increased competition, but shrubs and trees may begin to grow eventually.

Some farmers use a "knock-down" herbicide such as Glyphosate instead of tillage for seedbed preparation. For this reason, no-till is often associated with increased chemical use compared to traditional methods of crop production.

Crop rotation is also important in no-till farming. Some no-till farmers utilize a wide variety of crop cycles to exploit their soil condition and their weed situation at the time for maximum yields.

∆ Intensive tillage systems leave less than 15% crop residue cover.

∆ Reduced tillage systems leave between 15 and 30% residue cover.

∆ Conservation tillage systems are methods of soil tillage which leave a minimum of 30% of crop residue on the soil surface.

Pasture Cropping

Pasture cropping is a zero tilling technique of sowing annual cereal crops into living perennial (in this case, usually Australian native perennial plants) pastures and having these crops grow symbiotically with the existing pastures with real and advantageous benefits for both the pasture and the crops. Leading exponent Colin Seis, on his property "Winona", has developed this technique to include many different types of winter and summer crops being grown without destroying the perennial pasture base.

Pasture cropping is the combining of cropping and grazing into one land management system where each one benefits the other. The potential for profit and environmental benefits is great.

The original concept of sowing crops into a dormant stand of summer growing (C4) native grass, like red grass (bothriochloa macra) was thought to be a very inexpensive method of sowing oats for stock feed.

"The grazing crops performed so well that it was obvious that we could expect to harvest good grain yields as well," says Col. Enhancement of the pastures was also another very real and tangible benefit. Cereal crops in NSW, South Australia and Victoria were sown into winter growing (C3) native perennial grass with good results such as oat crops yielding over three tonne/Ha. Additionally, there have been good results in Victoria and NSW, sowing summer forage crops into winter dominant native perennial pastures.

Sowing a crop in this manner stimulates perennial grass seedlings to grow in numbers and diversity giving considerably more tonnes/hectare of plant growth. This produces more stock feed after the crop is harvested and totally eliminates the need to re-sow pastures into the cropped areas. Cropping methods used in the past require that all vegetation is killed prior to sowing the crop and while the crop is growing. From a farm economic point of view the potential for good profit is excellent because the cost of growing crops in this manner is a fraction of conventional cropping. The added benefit in a mixed farm situation is that up to six months extra grazing is achieved with this method compared with the loss of grazing due to ground preparation and weed control required in traditional cropping methods. As a general rule, an underlining principle of the success of this method is "One hundred percent ground cover One hundred percent of the time".

There is growing evidence, anecdotal and scientific, to support improvement in soil health, improved water use efficiency and general improvement in ecosystem function. Another asset is that these methods lead to a measurable increase in soil carbon levels which may produce both a cash value in future carbon trading ventures as well as reducing some of the atmospheric carbon dioxide which contributes to what is commonly referred to as the "greenhouse effect". Independent studies at Winona on pasture cropping by the Department of Land and Water have found that pasture cropping is 27% more profitable than conventional agriculture.

Biological Farming

Biological Farming is a name that covers a large number of practices and groups of adherents to particular styles of farming. It is characterized by what it is not: Chemical Agriculture. This is the conventional, western technology system of agricultural production, based on petrochemicals, artificial fertilizers, and toxic chemicals for controlling weeds, pests, and animal health problems. The term "Biological" is the basis for the "Organics" movement, although they are not mutually exclusive.

Biological Farmers focus on the biological community that lives in healthy soil and gives it the ability to grow vegetation. Radical soil scientist Maarten Stapper says, "Soil fertility is the capacity to receive, store and transmit energy to support plant growth. These processes require healthy soils – living, self-organising systems with physical, chemical and biological components all functioning and in balance. Continuous use of acidic or salty synthetic fertilisers, insecticides, fungicides and herbicides disrupts this delicate balance."

The Green Revolution – which started in the 1960s when the agri-chemical technology became widely available –was a boon for mankind, enabling the world to feed many millions more than previous agricultural systems would allow. But the long term impact has been costly for the natural resource base. The use of fertilisers, pesticides and other chemicals has lead to declining soil health and resistance in insects and weeds. Dr William Albrecht said "insects and diseases are the symptoms of a failing crop not the cause of it."

Yields are declining, requiring more and better fertilizers to

simply stand still, while weeds and pests grow resistant to each generation of chemical poison. Once on the treadmill, the farmer cannot get off. They have become addicted to soluble NPK fertilisers and this leads to soil degradation. The humic substances which are key to soil fertility and plant nutrition and carbon sequestration, have gradually been destroyed.

"Humus is the bond between living and non-living parts in soil and is part of the soil organic carbon that has severely declined since cultivation started," says Maarten Stapper. Conventional agriculture – with its use of harsh

chemicals and ignorance of the delicate balance of humus, microbes, minerals and nutrients in the soil - has resulted in huge losses in soil organic carbon and greatly reduced diversity and abundance of microbes (algae, bacteria, fungi, nematodes, protozoa) and larger organisms (mites, ants, beetles, worms) in the soil. This greatly diminishing the capacity of the soil to feed plants, and make roots sensitive to saline and acidity. In turn the whole plant becomes susceptible to pests and diseases Disruption of soil biological and chemical processes usually leads to physical problems, such as reduced infiltration, compaction and erosion.

Andre Leu, chairman of the Organic Federation of Australia, lists practices that result in a decline in carbon:

Nitrogen application: Synthetic nitrogen fertilisers are one of the major causes of the decline of soil carbon. They stimulate a range of bacteria that feed on nitrogen and carbon to form amino acids for their growth and reproduction. These bacteria have a Carbon to Nitrogen ratio of around 30 to 1. In other words every ton of nitrogen applied results in the bacteria consuming 30 tons of carbon. The quick addition of these nitrogen fertilisers causes the nitrogen feeding bacteria to rapidly multiply, consuming the soil carbon to build their cells. This process results in the stable forms being consumed, causing a decline in the soil carbon levels. Ensuring that a carbon source is included with nitrogen fertilisers protects the soil carbon bank, as the microbes will use the added carbon, rather than degrading the stable soil carbon. Composts, animal manures, green manures and legumes are good examples of carbon based nitrogen sources Where possible plant available nitrogen should be obtained through rhizobium bacteria in legumes and free living nitrogen fixing micro-organisms. These microorganisms work at a stable rate fixing the nitrogen in the soil into plant available forms. They can utilise the steady stream of newly deposited carbon from plant roots to create amino acids, rather than destroying humus and other stable carbon polymers.

The use of biocides (Herbicides,

Pesticides and Fungicides) causes a decline in beneficial micro-organisms. There have been regular studies confirming the damage agricultural chemicals are causing to our soil biota., Dr Elaine Ingham has shown that these chemicals cause a significant decline in the beneficial microorganisms that build humus, suppress diseases and make nutrients available to plants. Many of the herbicides and fungicides have been shown to kill off beneficial soil fungi. These types of fungi have been shown to suppress diseases, increase nutrient uptake (particularly phosphorus) and form glomalin. Glomalin is a stable carbon polymer that forms long strings that work like reinforcing rods in the soil. Research is showing that they form a significant role in building a good soil structure that is resistant to erosion and compaction. The structure facilitates good aeration and water infiltration.

Use Correct Tillage Methods: It is important that tillage does not destroy soil structure by pulverising or smearing the soil peds. Many people have not heard of the concept of good soil 'tilth'. This is soil that is friable with a crumbly structure. Not a fine powder or large clumps. Both of these are indicators of poor structure and soil health. These conditions will increase the oxidation of organic matter turning it into CO2. Tillage should be done only when the soil has the correct moisture. Too wet and it smears and compresses. Too dry and it turns to dust and powder. Both of these effects result in long term soil damage that will reduce yields, increase susceptibility to pests and diseases, increase water and wind erosion and increase production costs. Tillage should be done at the correct speeds so that the soil cracks and separates around the peds leaving them intact, rather than smashing or smearing the peds by travelling too fast. Good ped structure ensures that the soil is less prone to erosion. Deep tillage using rippers or chisel ploughs that result in minimal surface disturbance while opening up the subsoils for better aeration and water infiltr-ation, are the preferred options. This will allow plant roots to grow deeper into the soil ensuring better nutrient and water uptake and greater carbon deposition. Minimal surface disturbance ensures that the soil is less prone to erosion and oxidation thereby reducing or preventing carbon loss.

Control Weeds without Soil Damage: Various spring tynes, some types of harrows, star weeders, knives and brushes can be used to pull out young weeds with only minimal soil disturbance. Rotary hoes are very effective however this should be kept shallow at around 25mm to avoid destroying the soil structure. The fine 25mm layer of soil on the top acts as a mulch to suppress weed

seeds when they germinate and conserves the deeper soil moisture and carbon. This ensures that carbon isn't lost through oxidation in the bulk of the topsoil.

Avoid Erosion: Erosion is one significant ways that soil carbon is lost. The top few centimetres of soil is the area richest in carbon. When this thin layer of soil is lost due to rain or wind, the carbon is lost as well.

Avoid Burning Stubble:

Practices such as burning stubble should be avoided. Burning creates greenhouse gases as well as exposing the soil to damage from erosion and oxidation.

Encourage Vegetation Cover: Vegetation cover is the best way to prevent soil and carbon loss. It is not always necessary to eradicate weeds. Effective management tools such as grazing or mowing can achieve better long term results.

Bare Soils Should be Avoided: Research shows that bare soils lose organic matter through oxidation, the killing of microorganisms and through wind and rain erosion.

Cultivated soils should be planted with a cover crop as quickly as possible.

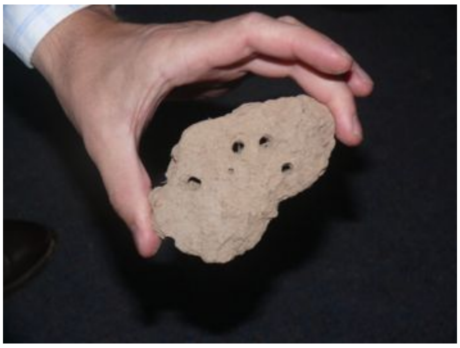
The cover crop will protect the soil from damage and add carbon and other nutrients as it grows.

The correct choice of species can increase soil nitrogen, conserve soil moisture through mulching and suppress weeds by out competing them.

The Eternal Earthworm: Expert Advice

By Graeme Sait

An agricultural system that is dependent upon petrochemicals is absurdly vulnerable as peak oil approaches. Smart operators have recognised this vulnerability and are seeking to reduce their reliance upon oil. The focus changes from oil to soil as growers come to recognise that their chemical approach has been self perpetuating. The more you use, the more you lose and the higher your requirement for chemical intervention. In contrast, a biological approach involves ever reducing inputs as the biology kicks in. The emphasis is upon soil life and there is one creature in this equation that epitomises the profit potential of biology.



Imagine a worker who can aerate your soil while fertilising, soil conditioning, liming, and creating humus. This same creature can mineralise soil and repopulate beneficial biology while also improving structure. If your soil contains good numbers of these workers then it is a good indication that you have a happy and productive soil food web. It has been suggested that the presence of this remarkable life form can be seen as a marker of the success and sustainability of any given society. It is the humble earthworm.

All Important Oxygen: Is oxygen the single most important element for plant production? Plant roots need an abundant supply and the organisms that crowd around those roots can't function without it. The calcium to magnesium ratio is the single most important ratio in the soil because it governs oxygen delivery. The lower your soil-life counts the higher your requirement for aeration to introduce oxygen. It is always much more cost-effective to use your earthworms to aerate rather than hauling a spiked roller all over the farm! Earthworms create the perfect passageways to improve gas exchange and improve water infiltration. The earthworm castings also increase crumb structure which also improves oxygen availability.

Free Fertiliser: There is a massive difference in the nutrient analysis of the surrounding soil compared to what comes out of the back end of an earthworm. In fact, these slimy strands are essentially fertiliser factories. The castings contain 7 times more phosphorous, 10 times more potassium, 5 times more nitrogen, 3 times more magnesium and 1.5 times more calcium than surrounding soil. At the Gatton field days, several years ago, the DPI conducted trials on several organic fertilisers, including manure, feedlot compost and vermi-compost The vermi-compost completely outperformed all other inputs in the trial. In fact, there were impressive results at application rates of just 1 tonne per acre or 2.5 tonnes per hectare. Here's the holy grail of biological farming. If you can achieve counts of 25 earthworms per shovelful then your days of buying fertiliser are over. This number of earthworms will produce 300 tonnes of earthwork castings per year. The cost of commercial castings exceeds $200 per tonne so you are effectively receiving $60,000 of free fertiliser from your earthworms and why would you need to apply any more?

Repopulating Your Workforce
The earthworm does not digest with enzymes when plant matter passes through it's system. Instead it employs microorganisms for this energy intensive task. A unique range of microbes are incubated within the earthworm and are excreted amongst the castings to introduce these organisms to the soil. That is why growers have achieved such good results from earthworm juice (water that has passed through the worm beds and accumulated these organisms). If you do not have earthworms in your soil then you do not have this valuable range of organisms and there will be good gains in introducing them. As always it is a "give and you shall receive" deal in nature. The earthworm is seeking as much plant matter and beneficial biology as possible because that is what it eats. The bacteria it delivers sponsor production of more biomass, which means more food for the earthworm. These bacteria are also a food source for protozoa which, in turn, are the favourite food of earthworms. In this manner, the system becomes self supporting as is the case with many natural systems. The problems usually emerge when we intervene and disrupt the balance.

If you can achieve counts of 25 earthworms per shovelful then your days of buying fertiliser are over.

Building Humus: Since 1850 the loss of humus from our soils equates to 470 gigatonnes and this accounts for a great deal of the offending CO2 in the atmosphere. There is an urgent need to return this CO2 to the soil as humus and it is here that the earthworm has a hugely important role to play. Earthworms compost 4 times faster than conventional composting and composting is about humus production, whether that occurs in the field or in the composting plant. If your earthworms are delivering 300 tonnes of humus-rich castings per hectare then you will see an associated increase in organic matter (for which you will soon be paid). Increasing your earthworm numbers is a prime humus building strategy and yet most conventional farms have very few remaining earthworms at work.

Lime For Free: Calcium is the most important nutrient and it is removed with every crop. Earthworms are like little lime works. They have a calciferous gland that adds calcium carbonate to everything that passes through them. They are also burrowing deep in the profile bringing calcium and other minerals up into the root zone.

What Drives Out the Worms? Earthworms follow food. They love to eat fungi and protozoa so if these creatures are missing in your soil, so too will be the creatures that feed upon them. Earthworms also love dead plant matter.

Salt fertilisers dehydrate fungi and bacteria and thereby reduce earthworm food. These inputs also irritate the worms and they disappear quite rapidly. There has not been a lot of work done looking at the effect of farm chemicals on earthworms, but we do know that fungicides kill fungi (good and bad) and several herbicides appear to kill fungi as efficiently as they kick out weeds.

Compacted soils with a poor calcium to magnesium ratio are inhospitable to earthworms. Cultivation also impacts earthworms. It obviously chops them up and opens the soil to feathered predators. But there is another dynamic involved. Native earthworms burrow down to 30 cms, line those burrows with slime and organic material which attracts other organisms and these visitors serve as a food source. Every time they head to the surface they vacuum this supplementary tucker from their burrows en route. Tillage tears apart these pantry passageways and discourages the return of earthworm workers. This is why research has shown that minimum till and no till agriculture usually encourages more earthworms and associated humus production.

Bringing Back the Fertility Builders: How do you recover your earthworm populations? There are several foods that stimulate earthworms. Anything that increases the number of fungi in your soil will boost earthworm populations because fungi is a major food source for these creatures. Humic acid is the most powerful promoter of fungi followed very closely by kelp. Both of these materials offer a wide range of other benefits and this is why they have become integral components of the biological approach. The other biological essential which can have a magical effect upon earthworms is liquid fish fertiliser. It is common to see an immediate marked increase in earthworm numbers following the application of fish to the soil. They seem to come from nowhere to enjoy this concentrated mix of protein, fatty acids, carbohydrates and minerals. The one secret here is that you need to source a liquid fish fertiliser that still contains the full oil component (Nutri-Sea liquid fish) as the fish oil is a major attractant.

The other way to increase worm numbers is to feed the soil with plant matter by building a cover crop or green manure crop into your program. Ideally, there should be no time at which your soil is left bare. Whenever the opportunity presents, the aim is to produce some soil food rather than fallow your soil. Some people argue that they do not want a cover crop to steal moisture that they are trying to conserve for the following crop. This is not what happens. The cover crop increases organic matter and biological activity. Bacteria produce a sticky, alkaline film that works just like water crystals in the soil. The more bacteria you have, the greater your potential to retain moisture. Similarly, an increase in organic matter means more moisture retention. A 1% increase in organic matter means that your soil can retain 170,000 extra litres per hectare. In a home garden this represents 17 litres per square meter.

The other worm building tip involves protozoa. Protozoa are a worm's favourite food. Protozoa numbers are often depleted due to their susceptibility to farm chemicals. Earthworms go elsewhere. If you want to return your farm to a fast food heaven for earthworms then you need to bring back the protozoa. For some reason, protozoa love lucerne and all three species are found in abundant numbers in lucerne hay. The idea is to harvest these creatures from the hay and multiply their numbers prior to introducing them to the soil. The one caution here relates to chemical contamination of the hay. The safe option is to source organic lucerne as it appears that the chemical used to control lucerne flea can seriously impact protozoa populations living on the lucerne.

Making tea: Here's how to make a lucerne tea. Add 7 kgs of lucerne hay to 200 litters of water. The best idea is to place the hay into a simple, drawstring bag made of shadecloth so that it will not clog the pump. This is not necessary if you are using brewing apparatus based upon air compressors rather than impeller pumps. Next you add some food to feed the protozoa. We have developed a food called LMF (Liquid Microbe Food) that works well for this purpose. Two litres of LMF is required for the 200 litter drum (1%) and then you leave the mix to brew for at least 24 hours. You will then need to filter the end product (if it is not in a drawstring bag) before applying it via boom spray or fertigation at a rate of 100 litres per hectare.

The presence of these remarkable life forms in your soil heralds a disease suppressive soil with more carbon building potential and less requirement for chemical intervention. The food produced on these soils will be more nutrient dense and the cost of production significantly less. Bring back the earthworms to your soil and you will also have a lot of fun.

NUTRI-TECH SOLUTIONS

Biochar: What Do We Know?

Biochar offers exciting prospects for soil productivity, carbon sequestration, avoided emissions, and renewable energy. Many scientists are enthusiastic, openly promoting the technology. But ABARES declined to recommend its use. Why?

Biochar is a stable, carbon-rich form of charcoal that can be applied to agricultural land as part of agronomic or environmental management. It can be produced by pyrolysis; where biomass such as crop stubble, wood chips, manure and municipal waste is heated with little or no oxygen…[12]

There are significant potential productivity and other benefits from adding appropriate biochars to Australian agricultural soils. These include improvements in physical and chemical soil characteristics, nutrient use efficiency and reductions in greenhouse gas emissions derived from nitrogenous fertilisers. Generally, biochar has been found to improve infertile and degraded soils. However, not all crops behave the same way and not all soils show broad improvements with biochar application; even when the biochar appears fit for purpose. Within farming systems, biochar may also bind and reduce the efficacy of some agricultural chemicals…

Current knowledge about the effects of adding biochar to Australian agricultural soils is not sufficient to support recommending its use. However, international and Australian research will aid decisions about its use when results become available. Johannes Lehmann, a leading researcher in the field, said 'biochar can be used to address some of the most urgent environmental problems of our time—soil degradation, food insecurity, water pollution from agrichemicals and climate change'. Such statements within the media have given rise to the idea of biochar as a potential option to increase food security. However, others remain sceptical about the potential of biochar to secure food supplies and mitigate climate change…

The modern concept of biochar for soil amendment originated from soils particular to the Amazonian Basin, where charcoal from incompletely combusted biomass, such as wood from household fires and in-field burning of crop stubble has, over thousands of years, produced highly fertile terra preta (literally 'black earth') soils. These soils have been found to contain high levels of organic matter and nutrients when compared with adjacent soils… Terra preta soils have received widespread media coverage in recent times due to the positive effects on crop growth and this has led to the belief that biochar was the important ingredient. However, on closer examination, terra preta soils contain residues from human and animal waste, food scraps and other nutritious waste material that were not charred. As a result of media coverage, scientific interest in emulating terra preta soils in modern

[12] This report is a condensed version of "Biochar: implications for agricultural productivity", published December 2011. The report produced by Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) for the Department of Agriculture, Fisheries and Forestry and is available at: daff.gov.au/abares/publications.

agriculture is increasing. The addition of biochar to soils for enhanced soil fertility and agricultural productivity is one such area that appears promising…

Australia has an extensive range of biomass suitable for pyrolysis, including broadacre grain trash/ stubble, agricultural processing residues (macadamia nut shells, olive pips, bagasse from sugar cane production and husks from cereals or rice), forestry residues (wood blocks, wood chips and tree bark) and grass residues (both improved pastures and native grasses)…

Availability of large quantities of biomass feedstock and the transportation distance to a pyrolysis plant are essential considerations for an efficient and economically viable biochar production system… It is possible to co-locate pyrolysis plants with biomass processing operations (for example, in the sugar cane industry) to minimise handling costs and provide a waste management solution. Production of biochar has the potential to be scaled to any level of production based on location and feedstock quantities and quality. As such, pyrolysis systems can be developed for on-farm production or at a regional or state level…

Due to the range of biomass options and pyrolysis systems available, the variability in biochars that can be produced is high. This variability has significant implications for nutrient content of the biochar and nutrient availability to plants when biochar is applied to soil...

Apart from affecting the quantity of biochar produced, pyrolysis conditions also have an effect on the quality of the biochar produced…

Researchers have been conducting biochar field trials on varying soil types and within different parts of the world since 1980… [However], the long-term effects of biochar application are still unknown, with available information generally only relating to the first few years after application… As well, information on the effect of biochar on pastures, fodder shrubs and trees, and within dry and temperate climates is limited. Research to identify the long-term effect of biochar additions on specific soil types and climatic areas is needed to further understand the effects of biochar within an Australian context. Owing to the variability of biochar types and potential applications, limited information is available to farmers on how best to apply it…

Application of biochar as a soil amendment may be a valuable tool to enhance infertile and/or degraded lands. When applied to soil, biochar may improve nutrient supply to plants, as well as the physical and biological properties of the soil. However, due to the irreversibility of biochar application, researchers need to conduct long-term studies to achieve a high level of certainty that adding biochar to agricultural soils, for whatever reason, will not negatively affect soil health and productivity…

Most researchers agree that adding biochar to infertile soils decreases its bulk density and increases its water holding capacity. Adding biochar to infertile soil increases porosity, by the nature of its particle size and shape,

> ‘Biochar can be used to address some of the most urgent environmental problems of our time—soil degradation, food insecurity, water pollution from agrichemicals and climate change’.
>
> Dr Johannes Lehmann

and because of biochar's particularly porous internal structure. In addition, increased soil porosity increases the surface area of soil so water is better able to penetrate…

Rather than supplying micro-organisms with a primary source of nutrients, biochar is thought to improve the physical and chemical environment in soils, providing microbes with a more favourable habitat… Biochar, because of its porous nature, high surface area and its ability to adsorb soluble organic matter and inorganic nutrients, provides a highly suitable habitat for microbes...

Biochar pores may act as a refuge for some microbes, protecting them from competition and predation…. [M]icrobial communities in biochar will change over time once it has been added to the soil…

Application of biochar to soils may aid transformation of nitrogen, potentially improving its availability| to plants… In some cases, biochar additions to agricultural soils also decreased apparent ammonification rates… Similarly… addition of biochar to soils led to a decrease in soil nitrate production (nitrification) and a decrease in the amount of nitrogen available to plants.

Several studies have demonstrated enhanced phosphorus uptake by plants in the presence of biochar, but little work has been done on the underlying mechanism for this enhanced uptake… The overall nutrient impact of biochar additions to soils appears to increase the ability of the soil to store or hold nutrients, rather than directly increasing nutrient content.

A key feature of biochar addition to soils is increased nitrogen use efficiency by plants. The evidence suggests that significant reductions in nitrogen fertiliser application can be achieved while maintaining similar yields, with the addition of biochar to soils. Alternatively, yields may increase significantly with the addition of biochar to soils and little change in established nitrogen fertiliser regimes.

In addition to the potential of biochar for soil amelioration and crop productivity, it may also have the potential to improve livestock growth rates, while decreasing nitrogen outputs…. Through limited studies conducted to date, the addition of char to the diets of economically significant livestock species has been shown to improve production parameters… In addition to potential productivity gains, adding char to livestock diets has the potential to minimise nitrogen excretion and improve the carbon sequestration potential of manure…

Biochar has received much attention recently as a means of sequestering carbon due to its high chemical stability, high carbon content and its potential to reside in soils over a long period. These physico-chemical properties mean that biochar application to soils may provide a greater sequestration potential, with a lower risk profile than would be the case with increasing organic matter through conventional management practices such as no-tillage farming…. A comparison of international findings with an Australian perspective would be beneficial; however, no Australian journal publications are available. Production and use of biochar as a soil amendment, in conjunction with bioenergy production may provide a means to decrease greenhouse gas emissions and provide net environmental benefits. However, careful consideration must be given to the potential negative effects of biochar application to soils such as the potential to increase soil organic matter degradation and a potential increase in erosion from removal of stubble as a feedstock. More research is needed to explore these potentially negative effects before the uptake and use of biochar as a direct method to reduce greenhouse gas emissions from agricultural soil… The economic viability of the pyrolysis system for producing biochar is highly dependent on a number of factors, including feedstock costs, the process itself and the value of end products.

No published work in Australia reflects the potential economic viability of different biochar production facilities.

Australian conditions will vary significantly from conditions in the United States. In particular, due to wide dispersal of potential feedstock locations in Australia, transportation costs would be significantly higher in Australia. In addition, maize production systems in the United States produce about seven times more biomass on a unit area basis, compared with Australian wheat production systems. These differences mean results from US studies cannot be directly related to the Australian situation. However, the underlying economic trends may be considered in the Australian context.

When choosing a feedstock to produce biochar, it is essential to undertake a full life-cycle assessment to estimate the economic costs of a particular system. For example, when considering crop stubble as a potential feedstock, the harvest, transportation and opportunity costs of using the crop stubble for a different purpose (such as preventing soil erosion and supplying nutrients to future crops through soil organic matter) must be examined. By considering these factors it has been estimated that the potential farm-gate price of maize residue for producing biochar is US$27.59 per tonne…

Generally, two processing options are available to producers: the pyrolysis plant can be located either on-farm with biomass processed on-site or at a communal site with biomass transported to the plant. Generally, a centralised plant will be large and capable of high throughputs, but will also require large capital investment. In contrast, the small, generally mobile pyrolysis plants require less capital investment, but labour costs are typically high and little to no potential excess bioenergy from pyrolysis is used. One study found that only large-scale stationary pyrolysis plants were viable, where biochar was produced in conjunction with bio-oil. The cost of biochar production was estimated at US$87 per tonne of biochar using a large-scale fast pyrolysis plant. Transportation distance of feedstocks may also decrease profitability of the system…

The financial benefits of biochar production comes from a number of potential sources depending on the type of pyrolysis used and includes energy production, biochar production and as a carbon offset in future emissions trading schemes…

Pyrolysis plants are unprofitable under current United States conditions. However, if the value of biochar increased from US$47 per tonne to more than US$246 per tonne, slow pyrolysis would be viable for the biochar producer. In Australia, anecdotal reports indicate a cost of $5000 per tonne to purchase biochar from processing companies…

The financial justification for developing a biochar pyrolysis system would depend on the price received for biochar and bioenergy products, and any value of avoided carbon dioxide equivalent emissions, the cost of feedstocks used and the cost of pyrolysis itself. Development and commercial viability of a biochar industry would be highly reliant on proven benefits to ensure demand for specific biochar products. Feasibility studies are scarce in this emerging industry and as such, the commercial viability of biochar production remains unclear; especially in the Australian context.

Application of biochar to soils has been placed on the draft Carbon Farming Initiative Positive List, meaning this activity is likely to be eligible for crediting. However, all eligible activities need an approved methodology to enable quantification of emission reductions or sequest-ration. There are currently no approved methodologies for biochar; further research may be needed before a methodology can be found to meet the integrity standards of the Carbon Farming Initiative.

Due to the irreversibility of biochar application to soils, any potential risks should be thoroughly examined before widespread use of biochar is adopted… Of particular concern is the lack of research about the appropriate level of biochar application for different soil type. Due to the limited number of studies and the small range of climatic, crop and soil types examined, caution must be exercised when extrapolating results. This is essential, considering that some biochars have been found to adversely affect plant growth and not all soils respond to biochar application in the same manner…

While the global potential for biochar and bioenergy production is large, there is only a finite area of land available without compromising food production. As the market for these products expands, land use and other resources may be affected…

As biomass density in Australia is lower when compared with more productive landscapes in continental America and Europe, biomass transportation costs may affect the viability ofa biochar industry within Australia. It may also be difficult to source adequate quantities of biomass throughout the year, with transportation costs expected to be higher… Due to the infancy of the biochar–bioenergy industry, supply of biochar from commercial pyrolysis plants is limited and localised in Australia. Consequently, appropriate biochars are expensive, with current biochar research activities pre-dominantly restricted to laboratory trials.

Although it is intended to use biochar for soil amelioration benefits, it is probably too soon to fully embark on major industry development as considerable scientific uncertainty remains…

Great uncertainty also surrounds the effect of biochar application on agricultural productivity. To date, limited research has been published to determine the effects of biochar application on agricultural productivity parameters (such as the cation exchange capacity, water holding capacity, the effect of biochar on soil microbial populations, pesticide efficacy and nutrient availability); with many researchers reporting contradictory results. In particular, a maximum application rate needs to be identified to ensure biochar additions to soils do not degrade land..

Although studies have identified biochar's ability to remain stable in the soil for decades (up to millennia), limited field trials have been conducted. Of the trials conducted, researchers have found that biochar rapidly disappears from the soil, particularly through erosion. Long-term monitoring of biochar field applications is needed to assess the fate and long-term stability of biochar in soils. [13]

[13] Sparkes, J & Stoutjesdijk, P 2011, Biochar: implications for agricultural productivity, ABARES technical report 11.6. CC BY 3.0

Albrecht Natural Farming

"The soil is the 'creative material' of most of the basic needs of life. Creation starts with a handful of dust." William Abrecht saw a direct link between soil quality, food quality and human health in the 1920's. As Professor of Soils at the University of Missouri, he drew direct connections between poor quality forage crops, and ill health in livestock and from this developed a formula for ideal ratios of cations in the soil, the Base Cation Saturation Ratio (BCSR). It is a method of interpreting soil tests that is widely used in sustainable agriculture. Soil cations are balanced according to varying ratios giving 'ideal' or 'balanced' soil. The primary nutrients that BCSR methods are most concerned with balancing are calcium, magnesium, potassium, and sodium. A soil balanced by these methods leads to greater crop yield and nutritional quality, as well as increasing the soil biological activity and the physical properties of tilth, aeration, and moisture retention. There is currently no peer-reviewed research to support these claims,] but BCSR systems are widely used in organic farms. "You have to have a vision. Unless you do, nature will never reveal herself," he said. Albrecht looked to nature to learn what optimizes soil, attributing many common livestock diseases directly to those animals being fed poor quality feeds. "Food is fabricated soil fertility."

Albrecht took a microbiological view of plant structure, approaching soil as a variable environment (either favourable or unsuitable). Investigating cattle nutrition, he observed that certain pastures seemed conducive to good health, and came to the conclusion that the ideal balance of cations in the soil was "H, 10%; Ca, 60 to 75%; Mg, 10 to 20%; K, 2 to 5%; Na, 0.5 to 5.0%; and other cations, 5%". Albrecht identified that declining soil fertility was due to a lack of organic material, major elements, and trace minerals, and was thus responsible for poor crops and in turn for pathological conditions in animals fed deficient foods from such soil:

William A. Albrecht

"NPK formulas, (nitrogen, phosphorus, sodium) as legislated and enforced by State Departments of Agriculture, mean malnutrition, attack by insects, bacteria and fungi, weed takeover, crop loss in dry weather, and general loss of mental acuity in the population, leading to degenerative metabolic disease and early death."

William A. Albrecht was born on a farm in 1888 in Illinois, USA. He earned four degrees from the University of Illinois, the first being a degree in Liberal Arts.

Loss of Soil Organic Matter and Its Restoration

William A. Albrecht, Professor of Soils, University of Missouri 1938

Organic matter may well be considered as fuel for bacterial fires in the soil, which operates as a factory producing plant nutrients. The organic matter is burned to carbon dioxide, ash, and other residues. This provides carbonic acid in the soil water, and the solvent effect of this acidified water on calcium, potassium, magnesium, phosphates, and other minerals in rock form is many hundreds of times greater than that of rain water. At the same time the complex constituents of the organic matter are simplified, and nitrogen in the ammonia is released and converted into the nitrate form. This, very briefly, is the complicated process of de-composition, from which carbon dioxide results as the major simplified end product, together with a host of others in smaller amounts. This gas is released in such large quantities from the soil that the supply in the atmosphere over the earth is maintained at a constant amount. Decomposition by micro-organisms within the soil is the reverse of the process represented by plant growth above the soil. Growing plants, using the energy of the sun, synthesize carbon, nitrogen, and all other elements into complex compounds. The energy stored up in these compounds is then used more or less completely by the microorganisms whose activity within the soil makes nutrients available for a new generation of plants. Organic matter thus supplies the "life of the Soil" in the strictest sense. The depletion of the supply of organic matter by cultivation is well illustrated by the report of a study in central Missouri in which an undisturbed virgin prairie soil was compared to an adjoining field cropped to corn, wheat, and oats for 60 years without the addition of manure or fertilizer. No erosion had taken place, yet 38 percent of the organic matter represented by the virgin soil had been lost during that period because of cultivation… The loss of organic matter represents soil compaction, which hampers the circulation of air and water and hinders tillage operations at the same time that the function of the soil in plant nutrition is disturbed. Thus in but 60 years, more than one-third of the organic matter, representing centuries of accumulation, was destroyed and the efficiency of the soil for crop production was red-uced.

The Nation should be made aware of the rapid rate at which the organic matter in the soil is being exhausted… The maintenance of soil organic matter might well be considered a national responsibility.

William A. Albrecht, 1938

Soil organic matter is the source of nitrogen. In the later stages of decay of most kinds of organic matter, nitrogen is liberated as ammonia and subsequently converted into the soluble or nitrate form. The level of crop production is often dependent on the capacity of the soil to produce and accumulate this form of readily usable nitrogen. We can thus measure the activity that goes on in changing organic matter by measuring the nitrates. It is extremely desirable that this change be active and that high levels of nitrate be provided in the soil during the growing season. Regardless of the presence or absence of a crop, the failure to add organic matter and regular tillage of the soil mean a depletion of the original stock of organic matter at a very significant rate, even where there is no erosion. Where erosion removes the body of the surface soil itself, the rate of depletion is much greater. In addition to carrying nitrogen, the nutrient demanded in largest amount by plants, soil organic matter either supplies a major portion of the mineral elements from its own composition, or it functions to move them out of their insoluble, useless forms in the rock minerals into active forms within the colloidal clay. Organic matter itself is predominantly of a colloidal form resembling that of clay, which is the main chemically active fraction of the soil. But it is about five times as effective as the clay in nutrient exchanges. Nitrogen, as the largest single item in plant growth, has been found to control crop-production levels, so that in the Corn Belt crop yields roughly parallel the content of organic matter in the soil… With declining organic matter go declining corn yields and therefore lower earnings on the farmers investment. Thus the stock of organic matter in the soil, particularly as measured by nitrogen, is a rough index of land value when applied to soils under comparable conditions. According to studies in Missouri, for example, the lower the content of organic matter of upland soil, the lower the average market value of the land.

The following questions naturally arise: What should be the content of organic matter in a soil? Should the present level be raised or merely maintained economically? … Attempting to hoard as much organic matter as possible in the soil, like a miser hoarding gold, is not the correct answer. Organic matter functions mainly as it is decayed and destroyed. Its value lies in its dynamic nature. A soil is more productive as more organic matter is regularly destroyed and its simpler constituents made usable during the growing season. Its mere presence in the soil is of value during certain stages of decay, when it influences soil structure and water relations and when it functions in holding plant food in readily available form much more effectively than does any mineral fraction of the soil. The objective should be to have a steady supply of organic matter undergoing these processes for the benefit of the growing crop.

Cultivation of the soil and extended periods without a vegetative cover decrease the content of organic matter below that considered natural, or virgin, for the locality. The degree of exhaustion of organic matter to levels below the virgin stock represents the possibilities of improvement… Soil bacteria, the agents of decomposition, use carbon mainly as fuel and nitrogen as building material for their bodies and for the production of the intricate organic compounds that result from their activity…

The restoration of soil organic matter, then, is a problem of increasing the nitrogen level or of using nitrogen as a means of holding the carbon and other materials. This is the basic principle behind the use of legumes as green manures. In building up the organic content of the soil itself, it will often be desirable to use legumes and grasses rather than to add organic matter, such as straw and compost, directly....

Bacterial activity does not occur in the absence of the mineral elements, such as calcium, magnesium, potassium, phosphorus, and others. These, as well as the nitrogen, are important: Studies show that the rate of decomposition is reduced when the soil is deficient in these elements. In virgin soils high in organic matter, these elements also are at a high level, and are reduced in available forms as the organic matter is exhausted. A decline in one is accompanied by a decline in the other...

American citizens are becoming conscious of the fact that loss of fertility and the depletion of organic matter in the soil are partly responsible for the menace of erosion… The need for long-time investments in materials that build up the soil in organic matter and fertility should be recognized in granting credit to farmers.

This is an extract from the original article which first appeared in *Soils and Men, Yearbook of Agriculture,* U.S. Dept. of Agric., *1938,* pp. 347-360.

Biodynamic Agriculture

Biodynamic agriculture is a method of farming based on spiritualism promoted by Rudolf Steiner. It sees the farm as an organism. It focuses on the holistic development and interrelationship of the soil, plants, and animals as a closed, self-nourishing system. Biodynamic farming shares organic agriculture's belief in manures and composts and bans the use of artificial chemicals. Original biodynamic methods include the use of fermented herbal and mineral preparations as compost additives and field sprays and astronomical sowing.

Biodynamic agriculture began in 1924 with a series of eight lectures on agriculture given by Rudolf Steiner at Schloss Koberwitz in Poland. The course was requested by farmers who noticed their soils deteriorating along with the health and quality of crops and livestock from the use of chemical fertilizers. Today biodynamics is practiced in more than 50 countries worldwide.

Biodynamic agriculture’s view of the farm as an organism, with its own individuality, leads it to practice integration of crops and livestock, recycling of nutrients, maintenance of soil, and the health and well being of crops and animals. The farmer is part of the whole, say devotees. Cover crops, green manures and crop rotations are used extensively. The celestial (i.e., astrological) influence on soil and plant development aims to revitalize the farm, its produce, and its inhabitants.

Steiner invented nine different preparations to aid fertilization. The prepared substances are numbered 500 through 508, where the first two are used for preparing fields and seven are used for making compost.

• Preparation 500, a formula for field preparations for stimulating humus formation is made by filling the horn of a cow with cow manure and burying it 40–60 cm below the surface in the autumn.

• Preparation 501 is made of crushed powdered quartz, stuffed into a horn of a cow and buried into the ground in spring and taken out in autumn. It can be mixed with 500 or mixed (1 tablespoon of quartz powder in 250 litres of water) The mixture is sprayed on crops during the wet season to prevent fungal diseases.

• Compost preparations, used for preparing compost, use herbs which are frequently used in medicinal remedies. All preparations are used in homeopathic quantities. Each compost preparation is designed to guide a particular decomposition process in the compost heap.

• Biodynamic agriculture sees pest and disease control as a matter of having a strong healthy balanced farm organism. When some intervention is needed, Steiner called for using the ashes of a pest or weed that has been trapped or picked from the fields and burnt. Weeds and plant vulnerability to pests are a result of imbalances in the soil.

The Many Benefits of the Dung Beetle

Dung Beetle Solutions Australia say there are many soil health benefits:

Increased pasture production: Where the deep-tunnelling dung beetles B. bison and G. spiniger are well established and abundant, each completely buries cattle dung within days of its production over several months each year. DBSA field trials have shown that dung burial by both species can increase pasture production by 25% in field plots. This has so far persisted for three years.

Increased plant nutrients in the subsoil

Deep-tunneling dung beetles such as B. bison and G. spiniger increase levels of plant nutrients (phosphate, nitrate, sulphur, organic matter) in the subsoil. These effects have persisted for at least 2.5 years. Dung burial also increases levels of soil carbon and contributes to the removal of greenhouse gasses from the atmosphere.

Reduced fertiliser use Because dung beetle activity increases plant nutrients in the subsoil, the need for chemical fertilisers is reduced. A one-off investment in dung beetles can offer long-term cost savings

Increased earthworm numbers : Dung burial by B. bison and G. spiniger opens up the soil, allowing earthworms to burrow and work the soil deeper. Earthworm abundance increases in these conditions.

Free clay spreading: For every litre of dung buried by B. bison, just over one litre of subsoil is brought to the surface. Each winter–spring in regions where B. bison is abundant, dung burial brings about 300 tonnes of subsoil (at 30 to 50+ cm) to the soil surface for every group of 100 mature cattle).

Increased rates of water infiltration into soil: The disruption of the surface soil by dung beetle tunnels increases the permeability of the soil to water. Increased rates of water infiltration into dung beetle-affected soil have persisted for 3 years after dung burial.

Improved quality of run-off water In one trial so far, dung burial by G. spiniger completely removed organic pollution from run-off water.

Natural Sequence Farming

Natural Sequence Farming (NSF) is a land management technique that aims to restore natural water cycles to extract maximum value from the water passing through the landscape. It is a low-cost method of "drought-proofing" and increasing productivity on Australia's farms. NSF is based on ecological principles and an understanding of the way water passed through the landscape in the period before white settlement introduced European farming methods which opened the soil up to erosion and hydrology problems such as salination.

NSF aims to improve the quality and productivity of agricultural soils by managing water. The basic principle is to 'low the water down as it passes through the landscape. For instance, where there had been a 'chain of ponds' which held water in the landscape and encouraged vegetation growth, overgrazing and ploughing turned these areas into eroded gullies, with great loss of soils and soil structure and fertility. NSF addresses this problem by redirecting the water or slowing it down (by means of porous barriers).


Peter Andrews conducts a workshop

NSF techniques include: diverting water into floodplains to increase its residence time in soils, structuring streams to reduce flow velocities, and using structures in streams to provide productive flow form patterns.

While water is a fundamental element of the NSF process, it is part of a broader soil management methodology which includes maintaining good vegetation cover, mulching organic matter to improve soil structure, and maintaining a diversity of plants including deep-rooted species.

Invented by Peter Andrews, NSF also includes using weeds to rejuvenate tired soil (later to be naturally replaced, e.g. by grass for pasture), avoidance of chemicals such as fertilizer or pesticides.

This can mean greater profits, due to the much lower cost of agricultural inputs. NSF also involves planting reeds and trees in creeks to help spread water through the soil.

Implementing Natural Sequence Farming does not mean taking the landscape back to what it was pre-European settlement.

NSF focuses on establishing how the natural system worked in a particular area and how it is working now and uses some of the

same natural techniques, and mimics others, to address soil and water degradation and loss of biodiversity.
Natural sequences that can be harnessed by informed management include the movement of grazing animals, birds and insects from valley floors by day to higher levels on the valley sides at night and the transfer of fertility with them. There is a gradual movement of nutrients and seeds back down the valley sides via the water cycle, vegetation and soil processes, constantly refurbishing the fertility of the landscape.

In the process, various plants collect specific substances and the plant communities change in predictable sequences. As part of the biodiversity of a property and catchment, these plants are also a part of multiple food chains and a key to enhancing fertility.

Nutrients contained in soil or water are mobile and can be quickly lost off-site. Nutrients contained in biodiverse living bodies are stable. NSF management keeps natural functions connected which allows for quick exchange and conversion of nutrients within ecosystems on properties. NSF takes a holistic approach to natural resource management by re-establishing the stream's connection to the surrounding landscape and restoring floodplains as 'sponges'. Although most landscapes have unique qualities, the principles of landform and management are the same. The physics remains constant.
Peter Andrews' interpretation of the landscape accepts that, pre-European settlement, the soil's natural salt content was kept in check by slow sub-soil movements of fresh water. Under natural systems that are replicated by NSF, movement of fresh water is by surface and sub-surface flows. The surface flow is by the stream which is perched at the highest level of the floodplain on an accumulation of sediment. Surface water is buffered at each narrowed step position in the chain of ponds. Under NSF, this is achieved by a naturalised 'leaky weir' of rocks, sediment, trees, branches, reeds and grass roots mimicking the original natural slowing impediments to flows.

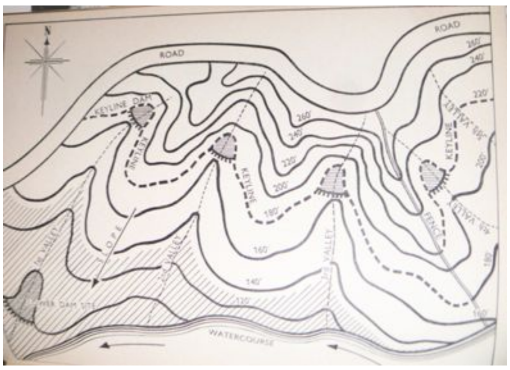
In floodplains in their pristine form, water is stepped slowly down the stream valley floor from one end of a catchment to the other. The stream valley floor is segmented with steps. These steps are where a new floodplain starts and the up-stream one finishes, and below which, large reed beds form on recharge areas.

NSF trials have resulted in increased bacterial productions helping to provide essential nutrients in a ready to use form. NSF can do what mineral fertilizers cannot do - produce a functional soil rather than just a hydroponic support medium. A diversity of plants is encouraged by NSF succession approaches using grazing, slashing and mulching to produce a resilient system with essential elements. As surface soils are often prone to leaching, NSF advocates deep-rooted plants to stabilize them while accessing and recycling trace elements to support later successions of palatable grasses. For soils and plants, the role of NSF structures in generating flow form patterns in streams can be as important as reducing the velocity of flows. Certain patterns can help produce new soils through the deposition of sands, clays and organic matter on the floodplain while protecting the lush vegetation already there.

Keyline Planning

Keyline Planning is an agricultural system based on processes designed to increase soil fertility dramatically.

It aims to create a soil environment that rapidly accelerates soil biological activity, increasing the total organic matter content within the soil. Fundamentally, it uses the form and shape of the land to determine the layout and position of dams, irrigation areas, roads, fences, buildings and tree lines. Keyline lay-outs of farm and grazing lands also include the storage of run-off water on the farm itself. The Keyline was a contour that runs through the point, in all small headwater valleys where the slope change occurs. This contour is the primary contour in Keyline planning. Among other things it delineates the transition contour for cultivation, above which all "contour" cultivation must proceed up the slope, and below which all “contour” cultivation must proceed down the slope. The result of such "Keyline Pattern" cultivation is that an overall drift of surface runoff water occurs which prevents runoff concentration and the resultant gutter erosion from occurring. It increases the time of contact between the rain and the earth. It has the effect of turning storms into steady soaking rain.



The Keyline contour need not be on the individual farm. It is only necessary to know whether the contour to be paralleled is above, or below a relevant Keyline. In this way "drift" in either direction can be determined and implemented. Paralleling up, or paralleling down from a contour can direct the drift of rainwater away from erosion sensitive valley floors. The inversion of soil layers is quite contrary to Keyline concepts. All cultivation, in fertility enhancing agriculture is best done using an adaptation of the "forked stick" plough of ancient times. “Our own original cultivation experiments used a variety of earth moving rippers until we discovered the Texas built Graham Hoehme Chisel Plow. We redesigned the old Graham Hoehme Chisel Plow to suit the more extreme conditions usually found in Australia. The plough was developed and promoted. The acceptance and almost universal adoption of chisel ploughs has been one of the most beneficial and noticeable changes in Australian agriculture this last century.” Allan Yeomans, son of the inventor of Keyline Planning, explains Keyline cultivation: “We found over time that the chisel plow required more fundamental refinements. It was good but it was still not the ideal implement for rapid soil development type agriculture. It was virtually incapable of one-go deep tillage without excessive soil profile disturbance. The current Yeomans Plow thus evolved. And the modern subsoil plough was born. These achieve virtually the ultimate in Keyline cultivation requirements. They are able to operate well into the subsoil without the usual, dilution by mixing, of the shallow topsoil with the huge bulk of infertile subsoil underlaying it. The concept of the narrow tine subsoiler we developed is now receiving wide spread acceptance by both farmers and other manu-facturers.” This new plough has allowed for much accelerated Keyline soil development progression by eliminating the need for the time consuming, yearly increase in cultivating depth necessary with the chisel plow.

Landsmanship: Reading The Landscape

Without our help, successive biological communities, over long periods of time, working with the resources available, (water, nutrients, sediments and sunshine) formed our landscapes and built ecosystems and natural communities. These were bequeathed to us in good working order, usually without the permission or wisdom of the indigenous people.

Carbon[14], soil and water capture naturally occur when all essential, functionally-task-specific species are returned or retained in valley land and water systems. Species that have been lost from the local valley landscape should be returned or a functional mimicking species be considered, to ensure optimal connect-ions within the ecological web. We need to think in ecological terms to best diagnose this requirement in land where we understand the history. Every species has a role to play (niche) and requires a place to live (habitat) and has a unique offering in the management of ecosystem cycles, maintaining species diversity and population numbers and in the transfer of energy through food webs and chains.

We need to remove people-induced impediments, where we have inadvert-ently caused chemical imbalance in soil profiles or unnecessarily used redundant infrastructure, to replace or control a natural function in our landscapes. We need to do this to allow nature to heal, maintain, or manage the landscape. Replacing or retaining task specific species to fill ecological functions (niches) in site specific landscapes also helps to create and accumulate more detritus, sediments, animal and plant derived debris, nutrients and minerals. As recycled matter, these in turn add to the accumulation of biomass and help optimise local hydrology, at low cost.

It is important to optimise species diversity at farm level since more ecological roles being played means a healthier landscape. It is usually better that no one species dominate. It is also imperative to have enough retained-species-induced nutrients and minerals cycling locally and available as carbohydrate, protein and minerals. This is what helps to build and maintain healthy biological communities. When there is an appropriate balance within the system, naturally-occurring plant succession will have already begun to work in favour of the landholder. Many weed species are gradually eliminated through incorporation, grazing, slashing or cultivation to the level where important native plants and animals - and farm crops and animals - out-compete most exotic species in a successional change of guard.

[14] Farmer and former Department of Agriculture NSW scientific officer Paul Newell believes you can heal the land with only animals and plants if you can learn to read the landscape

As landholders, we are only entitled by nature to export second order plant or animal production, fruit and nut of the tree, hay and seed from the perennial plant or young of the parent animal. First order annual plants or parent animals and perennial plants, need to remain in the living landscape as part of the recycling processes essential to maintain healthy soils. Nature will sanction the export of up to 70% of annual cereal grain produced on my property only when at least 30% is recycled back through h animals to the cropped soil that grew that grain.

Soil renewed and created locally in this way by the farmer thinking as nature, compares favourably with known volcanic basaltic soils originating from the inner earth.

Harvesting grain, in situ, grazed by sheep not only increases meat, wool and lamb production but as a bonus their excreta is very high in nutrients and acts as an immediate boost to pasture and crop production, as well as feeding the essential ecosystem cycles. The remains of dead animals (blood, bone, excreta, and wool), fallen timber (broad leaf or woody tap-rooted plants) and grass (eaten by animals or microbes) need to be allowed to rot rapidly or slowly back into the local landscape in a natural composting process that helps create world‘s best practice soils. There is no burning of woodpiles, cereal or legume stubble on my property, since this is a net loss of both short and long term components in the complex recycling process. Furthermore dead fallen timber is habitat for many important invertebrates as well as providing important micro wind breaks. Soil renewed and created locally in this way by the farmer thinking and working as nature, compares favourably with known volcanic basaltic soils originating from the inner earth. This is Nature’s Lore in action to the benefit of all local species including my family. An exponential increase in farm biomass up to peak production can occur rapidly on a property that respects and encourages Nature‘s Lore.

Growth and accumulation of biomass is generated naturally, by retaining and recycling locally, more of what grows locally, microbes, plants, and animals. A bonus is the cooling of our local land and water system, thereby preventing negative feedback outcomes that inhibit optimal plant and animal growth. Accumulation and retention of more of what we grow as biomass, recycled at different rates over time, overcomes landscape decay (land degradation) and fosters landscape aggradation and the creation of new soils. That would be a novel occurrence on many Australian farms in our modern era.

The more self grown biological carbon we have in the landscape the more water is available and retained in soil and species. My valley land and water system is itself completely dependent on living organism, a kind of super-organism, able to provide all necessary food and shelter (habitat), and water, just as we humans do. People tend not to see land as a living being but never the less, it is at my place; a living and growing ''organism that seeks to maintain 30% carbon and 70% water if I give it the freedom to do so or otherwise, it dies. The symptoms of land death and decay include bare earth, undesirable plants, salinity, acidity, sodic slumping, sheet erosion, gully erosion and tree die-back. Dead land can be regenerated by retaining and recycling its own biomass, to naturally increase microbes, plants, and animals in local valley lands. Living landscapes can increase and maintain their own bomass to their inherent potential in our absence. As this gradually happens over a remarkable three to five year period, nature adds another free gift to aid the savvy landholder – resilience. Resilience is the capacity of my landscape to either resist the adverse conditions of stress caused by for example drought and to self repair if disease, storm, tempest or fire disturbs it. Optimal drought proofing, optimal water retention and de-energising, optimal soil carbon and the ongoing creation of new soils are the bounty of 'Landsmanship'.

11-Point Action Plan

1. Understand how agri-ecosystems function and the biophysical signs that are present that indicate system malfunction is occurring.

2. Increasing farm biomass sustainably. (Biomass in this context is defined as the total mass of matter, existing as living organisms present at the designated place in the biosphere: microbes, plants and animals together with their embodied water, although technically biomass is the dry weight without water). Excess biomass can be harvested sustainably and profitably if we understand the limits of the production system.

3. Optimising species diversity within the farming system. This is believed to optimise system resilience above ground (terrestrial) and below ground (within the soil) and in waterways, and to optimise the exchange of material resources such as nutrients and carbon via the nutrient and carbon cycles. This means conserving or increasing species in soil, water and on the land. More species live below the ground than above, but the above ground species, including terrestrial vertebrates and insects are critical in maintaining a functional landscape. Every fauna species has a specific and important role in maintaining ecosystem function.

4. Optimise living ground cover throughout the year that represents a complete biological community since this will prevent ground overheating to occur, as well as facilitate natural cooling processes, optimize sediment trapping and water retention within the landscape.

5. Optimising fauna and flora habitats. Free species will only be present if their habitat needs are met in a manner that will sustain viable populations.

6. Optimising capture of resources moved by water across the landscape, including sediment naturally eroding up slope, dead plant material, dissolved nutrients, animal faeces etc. This material can be trapped by using the density of growing plants.

7. Facilitating fauna to spread their manure as evenly as possible across the landscape so that the nutrient cycles are connected from valley heights to valley floors. This will be achieved using a combination of native fauna and farm stock, the latter being either managed via rotation or by removing fences that inhibit random and full use of the farming valley system.

8. Optimising capture of water within the landscape, enabling the storing of in ground water thereby decreasing evaporation rates and ensuring that optimal production rates are achieved.

9. Optimising base flow, as opposed to rapid runoff flow in creek lines, rivulets and rivers to optimize riparian ecology. This is usually automatically achieved by better water capture at infinite points across the landscape and optimal infiltration as organic carbon accumulates.

10. Optimising soil organic carbon and soil formation. This will be greatly facilitated by the ecological tithing of farm production and linking it with manure spreading carried out by animals.

11. Increase and maintain habitat connectivity within the farm landscape and between adjacent farming landscapes to optimise biodiversity and to enable the dispersal and movement of fauna between habitats.

How Nature Farms

"What are the main principles underlying Nature's agriculture? These can most easily be seen in operation in our woods and forests. Mixed farming is the rule: plants are always found with animals: many species of plants and of animals all live together. In the forest every form of animal life, from mammals to the simplest invertebrates, occurs. The vegetable kingdom exhibits a similar range: there is never any attempt at monoculture: mixed crops and mixed farming are the rule. The soil is always protected from the direct action of sun, rain, and wind. In this care of the soil strict economy is the watchword: nothing is lost. The whole of the energy of sunlight is made use of by the foliage of the forest canopy and of the undergrowth. The leaves also break up the rainfall into fine spray so that it can the more easily be dealt with by the litter of plant and animal remains which provide the last line of defence of the precious soil.

These methods of protection, so effective in dealing with sun and rain, also reduce the power of the strongest winds to a gentle air current. The rainfall in particular is carefully conserved. A large portion is retained in the surface soil: the excess is gently transferred to the subsoil and in due course to the streams and rivers. The fine spray created by the foliage is transformed by the protective ground litter into thin films of water which move slowly downwards, first into the humus layer and then into the soil and subsoil. These latter have been made porous in two ways: by the creation of a well-marked crumb structure and by a network of drainage and aeration channels made by earthworms and other burrowing animals. The pore space of the forest soil is at its maximum so that there is a large internal soil surface over which the thin films of water can creep. There is also ample humus for the direct absorption of moisture. The excess drains away slowly by way of the subsoil. There is remarkably little run-off, even from the primeval rain forest. When this occurs it is practically clear water. Hardly any soil is removed. Nothing in the nature of soil erosion occurs. The streams and rivers in forest areas are always perennial because of the vast quantity of water in slow transit between the rainstorms and the sea. There is therefore little or no drought in forest areas because so much of the rainfall is retained exactly where it is needed. There is no waste anywhere. The forest manures itself. It makes its own humus and supplies itself with minerals. If we watch a piece of woodland we find that a gentle accumulation of mixed vegetable and animal residues is constantly taking place on the ground and that these wastes are being converted by fungi and bacteria into humus.

The processes involved in the early stages of this transformation depend throughout on oxidation: afterwards they take place in the absence of air. They are sanitary. There is no nuisance

> "Little or no consideration is paid in the literature of agriculture to the means by which Nature manages land and conducts her water culture. These natural methods of soil management must form the basis of all our studies of soil fertility."
>
> Sir Albert Howard

of any kind--no smell, no flies, no dustbins, no incinerators, no artificial sewage system, no water-borne diseases, no town councils, and no rates. On the contrary, the forest affords a place for the ideal summer holiday: sufficient shade and an abundance of pure fresh air. Nevertheless, all over the surface of the woods the conversion of vegetable and animal wastes into humus is never so rapid and so intense as during the holiday months--July to September. The mineral matter needed by the trees and the undergrowth is obtained from the subsoil. This is collected in dilute solution in water by the deeper roots, which also help in anchoring the trees. The details of root distribution and the manner in which the subsoil is thoroughly combed for minerals are referred to in a future chapter. Even in soils markedly deficient in phosphorus trees have no difficulty in obtaining ample supplies of this element. Potash, phosphate, and other minerals are always collected in situ and carried by the transpiration current for use in the green leaves. Afterwards they are either used in growth or deposited on the floor of the forest in the form of vegetable waste--one of the constituents needed in the synthesis of humus. This humus is again utilized by the roots of the trees. Nature's farming, as seen in the forest, is characterized by two things: (1) a constant circulation of the mineral matter absorbed by the trees; (2) a constant addition of new mineral matter from the vast reserves held in the subsoil. There is therefore no need to add phosphates: there is no necessity for more potash salts. No mineral deficiencies of any kind occur. The supply of all the manure needed is automatic and is provided either by humus or by the soil. There is a natural division of the subject into organic and inorganic. Humus provides the organic manure: the soil the mineral matter. The soil always carries a large fertility reserve. There is no hand to mouth existence about Nature's farming. The reserves are carried in the upper layers of the soil in the form of humus. Yet any useless accumulation of humus is avoided because it is automatically mingled with the upper soil by the activities of burrowing animals such as earthworms and insects. The extent of this enormous reserve is only realized when the trees are cut down and the virgin land is used for agriculture. When plants like tea, coffee, rubber, and bananas are grown on recently cleared land, good crops can be raised without manure for ten years or more. Like all good administrators, therefore, Nature carries strong liquid reserves effectively invested.

Sir Albert Howard

There is no squandering of these reserves to be seen anywhere. The crops and live stock look after themselves. Nature has never found it necessary to design the equivalent of the spraying machine and the poison spray for the control of insect and fungous pests. There is nothing in the nature of vaccines and serums for the protection of the live stock. It is true that all kinds of diseases are to be found here and there among the plants and animals of the forest, but these never assume large proportions. The principle followed is that the plants and animals can very well protect themselves even when such things as parasites are to be found in their midst. Nature's rule in these matters is to live and let live. If we study the prairie and the ocean we find that similar principles are followed. The grass carpet deals with the rainfall very much as the forest does. There is little or no soil erosion: the run-off is practically clear water. Humus is again stored in the upper soil. The best of the grassland areas of North America carried a mixed herbage which maintained vast herds of bison. No veterinary service was in existence for keeping these animals alive.

When brought into cultivation by the early settlers, so great was the store of fertility that these prairie soils yielded heavy crops of wheat for many years without live stock and without manure. In lakes, rivers, and the sea mixed farming is again the rule: a great variety of plants and animals are found living together: nowhere does one find monoculture. The vegetable and animal wastes are again dealt with by effective methods. Nothing is wasted. Humus again plays an important part and is found everywhere in solution, in suspension, and in the deposits of mud. The sea, like the forest and the prairie, manures itself. The main characteristic of Nature's farming can therefore be summed up in a few words. Mother earth never attempts to farm without live stock; she always raises mixed crops; great pains are taken to preserve the soil and to prevent erosion; the mixed vegetable and animal wastes are converted into humus; there is no waste; the processes of growth and the processes of decay balance one another; ample provision is made to maintain large reserves of fertility; the greatest care is taken to store the rainfall; both plants and animals are left to protect themselves against disease In considering the various man-made systems of agriculture, which so far have been devised, it will be interesting to see how far Nature's principles have been adopted, whether they have ever been improved upon, and what happens when they are disregarded.

Extract from AN AGRICULTURAL TESTAMENT (1941) by Sir Albert Howard[1]

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[1] Sir Albert is widely considered to be the father of organic farming. As an adviser to the Indian states, he found he learned more from the traditional farmers and their composting than he taught them. He was Director of the Institute of Plant Industry Indore and Agricultural Adviser to States in Central India and Rajput

"What are the main principles underlying Nature's agriculture?… there is never any attempt at monoculture: mixed crops and mixed farming are the rule."

SIR ALBERT HOWARD

Microclimates: Can Carbon Farming Make It Rain?

There is another way that Australian farmers can influence the climate: by creating a micro-climate around their property.

A micro-climate will affect wind, rainfall, sunshine, and air temperature. It is a technique normally used by croppers. They use slope and row placement and alignment to determine a 'solar budget'. They use alley-cropping and shelter belts and mulches. Usually it is orchardists and horticulturalists, managing small holdings, who have used micro-climate manage-ment to their advantage. But we must adopt ideas from wherever they can be found, for broadacre farming.

Often a land manager will say, in the depth of a drought, 'there's no drought at my place'. By that they mean that they have managed their vegetation such that they have retained moisture in the landscape. When you protect your groundcover and don't overgraze or strip the earth bare by poisoning weeds or ploughing, you build or moisture reserves. Then water starts to cycle on your property. Some managers report receiving 1mm a day in dew from fogs and mists.

When your next door neighbour complains that you get more rain than he does, it is a joke… until you compare rainfall records.

A micro-climate managed for moisture will attract more passing clouds via the "Reverse Nauru Effect." Pacific Islands which have a lot of vegetation reportedly attract rainclouds whereas Nauru seems to repell them. Why? Could it be that the almost bare island of Nauru is sending up a column of heated air whereas the moist, lush micro-climate send up a column of cool air?

The Carbon Farmer has several practices that can be used to cool the environment in the vicinity: 1. Green vegetation, no matter what it is, it is valuable. 2. Mulch to keep bare earth from heating up. 3. Trees are useful in belts and scattered thoughout pad-docks, both for their vegetation and their wind circulation effects. There is much to be learned about local climate management at farm and catchment scale.

Fertility From Exhaust Fumes?

Tractor exhaust emissions recycling on dryland grain crops has many fans in Australia. The system's Canadian inventor Gary Lewis claims that injecting a stream of cooled exhaust gases into cultivated soil will enrich its fertility by boosting carbon and nitrogen levels. This will encourage microbes that consume green-house gases and convert them into plant nutrients. In turn, this will reduce fertiliser use, soil acidity and the amount of carbon dioxide entering the atmosphere.

Ian and Daniel Linklater, who farm near Trentham Cliffs, east of Mildura, heard Gary give a presentation, decided to try it for themselves. They spent about $25,000 modifying existing equipment and building some new components, with the help of a $10,000 grant from the Lower Murray Darling Catchment Management Authority.

The system uses a heat exchanger with two large fans that cool the exhaust to ensure it is no hotter than 30C, which might affect the seed's ability to germinate.

They then sowed their entire 3840ha crop of yitpi and sunvale wheat using the Lewis method, leaving only a trial plot, being managed by Mallee Sustainable Farming, for comparison.

MSF extension officer Dr Nicole Dimos said the Linklaters' aim was to promote biological activity in the soil and try to address the common problem of phosphorous and calcium lock-up. Ian said it saved them an estimated $300,000 in fertiliser costs in a season.

The system costs $US12,500-$22,500 (plus taxes) and there is a $US15,000 upfront licence fee, as well as a $US1500 annual fee.

The Bio-Agtive™ Method recycles agriculture internal combustion engine emissions into plant nutrients by filling the soil air spaces with oxidized organic matter (emissions) created by the tractor engine to move the seeder tines through the soil. Similar emissions are given off when a respiration event of an organism that is moving through the soil and feeding on organic matter, releasing energy and emissions (CO2 H20 NOX, oxidized organic matter). Bio-Agtive™ enhances the plant's physiology to greater utilize the sun's energy instead of fossil fuel fertilizer energy, sequestering more CO2, growing bigger leaves, bigger roots, healthy plant that has more nutritional value.

The system is now in use in Canada, the USA, Australia, England, Japan, Kazakhstan South Africa.

Dr. Loraine Bailey, FCSA, FASA, FAIC, a scientist, formerly with Agriculture Canada, now the principal of Eco-Agronomy Consultancy of Brandon, Manitoba. The following are selected, unsolicited quotes from his various writings about the technology:

- "We have agronomy test data to show that the exhaust stimulated soil nutrient release and uptake by both canola and wheat."
- "The exhaust treatment definitely had a positive effect on crop growth and rate of development - this was also observed in the vigor of both crops."

• "...it appears that the exhaust resulted in significant release of soil N and/or stimulated the crops to take up soil N. There were also small increases in the uptake of P, K, and S on the exhaust treatments that may be due to the function of the exhaust on the soil. Slight shifts in the amount of some micro-nutrients taken up by the crops were also observed."

• "The Fusarium and Midge data indicate that the Control and Exhaust Only treatments may have an advantage over the fertilizer treatments."

• "...the obvious conclusion is that the exhaust had a positive effect on crop growth, yield, and quality, and may have positively enhanced soil nutrients and nutrient chemistry."

Farmer/Innovator
Gary Lewis

• "The system also has the advantage of sequestering carbon in the soil as opposed to releasing it into the air where it becomes an environmental pollutant."

• "N/C [Quest Inc.] Technology has the potential of significantly reducing the amount of CO_2 and NO_x released into the atmosphere by farming operations. The net effect will be to reduce the impact of greenhouse gases on accelerating climate change - a global positive - improve soil quality and productivity, reduce inputs of inorganic fertilizers and other crop protection products with minimal or no effect on crop yield and quality, [and] improve on-farm cash flow, thus improving the socio-economic well-being of the rural population."

• "The direct effect of the technology is to reduce the amount of crop input products yet maintaining crop yield and quality, [resulting in] reduced cost of input, improved cash flow and profit margins for producers, improved competitiveness of ...farmers in the marketplace, and improved purchasing power of the rural population, thus improving their quality of life, etc."

Dr. Jill Clapperton, formerly with Agriculture Canada's Lethbridge Research Station for 16 years and now the principal of EarthSpirit Land Resource Consulting, leads the way in trying to find out exactly how exhaust does what it does in the soil. Here's what she had to say about our Bio-AgtiveTM Emissions Technology at its 2008 convention:

• "It works, and its my job to find out how it works. We will be able to tell you exactly what's happening in the soil in 3-5 years."

• "Gary's great goal is to make sure that people are growing food that is really good for them, and that they're doing good things for the soil - that they're taking care of their soil so they can grow great food."

• "...what is really nice about using the exhaust is that we're not using too much phosphorous."

N/C Quest Pty Ltd (Australia)
Bio-Agtive™ Emissions Technology

DIY Soil Carbon Trading Program

"Once our licensees get to know about the Bio-Agtive™ Emissions Tech-nology, they often ask us about marketing their "carbon credits" or what the "carbon offset" value of their crops might be - or even if we are an "aggregator"! So many of them asked us, in fact, that we created "The CO2X*change*™" Carbon Verification Program.," says inventor of the 'exhaust fumes as fertiliser' system. Gary Lewis.

"We think of farmers as "carbon managers". They not only grow crops, they also clean the air, and should get paid for it! The problem is that governments, climate exchanges, and big polluters won't pay enough for the CO2 they remove from the atmosphere to give farmers any incentive to manage carbon better or to take the risks necessary to fight Climate Change by changing their farming practices. "CO2X" does just that!

"Through The CO2X*change*™ every acre of crop you grow using our BAE Technology is made available to consumers around the world for sponsorship. We can't understand why anyone would sponsor an acre of rainforest that's increasingly hard to protect, manage, and verify, when they could sponsor licensed, verified farms to grow more food and clean more air at the same time - right down the road!

"When consumers sponsor a farmer to improve their farming practices, increased sequestration of carbon naturally follows. Consumers must continue to reduce their emissions year after year, and farmers must continue to change their farming practices year after year - for the betterment of the planet. Sponsoring agricultural change is the logical way to accomplish this, year after year. Every acre of crop a Bio-Agtive™ Member grows using the verified BAE technology will be made available to consumers and agencies throughout the world for exchange. The CO2Xchange™ will market and sell these Verified Carbon Sequestration acres to consumers and industrial company that need VCS credits.

These payments to CO2Xchange™ will be divided between BCS research support, Third world country agricultural sustainability and payments to you the BS acre provider.

Science, Smokestacks, Soil and Summer

Gary Lewis, president of N/C Quest Inc. Canada, is the inventor of the Bio-Agtive™ method of fertilisation by incorporating carbon and other elements from processed tractor exhaust emissions into the soil.

For the farmer who wants to store serious amounts of carbon in soil, here is some advice, based on the soundest science[15][16]: use the sunlight energy more on your farm. Plant summer crops, using the C4 category of plants to take advantage of the Sun's energy to store carbon. C4 Plants are tropical and have the ability to use the suns energy more efficiently, using the summer heat that is so valuable in storing carbon.

C4 plants are more water and nitrogen use efficient. They photosynthesize with only 6% efficiency loss at high temperatures, as wheat loses more than 50% of the CO2 through respiration, losing more CO2 than what the leaf takes in (growth stops above 25C, p139). However, when more microbial activity is stimulated by the Bio-Agtive™ method, the plant can still photosynthesize as the canopy CO2 level increases from soil respiration, which helps wheat and corn grow better. Corn grows better as it can continue photosynthesizing at temperatures above 25C, maintaining photosynthesis that supports nitrogen fixation as it requires 8g Carbon to fix 1g nitrogen 2-3 tonne per hectare carbon sucrose (p211).

Our research has found that Bio-Agtive™ corn and wheat have more carbon flow to the roots than fertilized crops. The ammonium phosphate uptake by plants enhances hydrogen proton excretion of the roots (starving the microbial life) and decarboxylation of the leaf (stopping photosynthesis). The form of nitrogen supply considerable affects both the mineral element composition and the organic acid content of plants, (table 2.24, p.48-9)

Bio-Agtive™ corn and wheat grow better when the canopy CO2 level is higher. Wheat can still photosynthesise, acting more like a C4 plant. The leaf, which works on partial pressure (gasses move to the area where there is less concentration, p138), starts to oxidise (or smoke) from the heat or fertilizer, and it starts to give off CO2. In these circumstances, photosynthesis stops. The difference is that CO2 in the air is normally 390 parts per million, but as the CO2 in the canopy drops below that level, the crop is using less CO2. The wheat leaf cannot take in any more CO2, so it stops growing because the CO2 is at equilibrium at the leaf surface. Bio-Agtive corn and wheat is different because it has put 5 times more carbon energy into the soil to

[15] The text referred to by page number throughout has been referenced in scholarly articles and papers more than 12,240 times: Marschner, Horst (1995). Mineral Nutrition of Higher Plants, second edition.

[16] A note to scientists: Many prominent scientists quite rightly doubt the Bio-Agtive method of Nitrogen fixation and Carbon storage. Doubt is healthy in Science. But those who have been working on the subject say it is no longer a question of if it works, but how it works.

grow roots, feed mycorrhizal fungi to access phosphors and minerals (p556-595), and feed bacteria to make nitrogen available (free living Nitrogen fixation p202), all before the weather reaches 25C. This energy is stored as carbohydrates. As the summer heat warms up the soil, it starts to respire, releasing CO_2 and water. Higher moisture in the soil and higher CO_2 levels in the canopy allow Bio-Agtive™ corn and wheat to continue to grow. The carbon and hydrogen stored earlier is cycling, maintaining a higher soil moisture and CO_2 level in the canopy, which means that the CO_2 is higher outside the leaf than inside (partial pressure is moving CO_2 into the leaf, p138). The difference between C3 and C4 plants is the way they photosynthesize. C4 plants have an extra cell called the bundle sheath cell that helps the leaf maintain a lower CO_2 level on the leaf surface. This allows corn to lower the canopy CO_2 more than wheat (transpiring less water, 200-300g of water for corn and more than 500g for wheat, to produce 1g dry matter, p139).

Above 25C, corn gets more efficient at removing CO_2 and using nitrogen. Bio-Agtive uses CO_2 to help a leaf store more energy from the sun, much like adding fuel to a fire in reverse. This explains why corn has more potential than wheat. They both grow better when the Bio-Agtive™ method is applied.

The Theory

Bio-Agtive emissions incorporate into water, soil, leaf, roots, and anything living, all working on similar carboxylation and decarb-oxylation chemistry principles. (these changes in carboxylation and decarboxylation of organic acids are also reflected in the different rates of CO_2 fixation in the roots (dark fixation), p46). Equilibrium between carboxy-lation (CO_2 fixation) and decarboxylation is regulated mainly by the PH sensitivity of two enzymes, PEP carboxylase, the malic enzyme and carbonic anhydrase (CA) (this enzyme contains a single zinc atom which catalyses the hydration of CO_2, p349). Many CO_2 interactions go on that we can't see and take for granted every second. Some have a turnover rate of 2800 per min (depending on its concentrations, CO_2 itself has either stimulatory (1-2% CO_2) or inhibitory effects over 5% on root growth, p. 521.

On Trial in Tanzania

NC Quest Australia has successfully installed 3 Bio-Active units in Tanzania. Mick Dennis of Colac, VICTORIA (who lives and farms in Tanzania) contacted Gary Lewis about entering Bio-Agtive™ into the African Enterprise Challenge. The application placed first from a field of 250 submissions and therefore received funding of $400,000 of which he has to repay 50% after 3 years. Trials have begun on this technology that could provide answers to the questions of food security in Africa.

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"We are able to breathe, drink, and eat in comfort because millions of organisms and hundreds of processes are operating to maintain a liveable environment, but we tend to take nature's services for granted because we don't pay money for most of them."
~ Eugene Odum

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Microbes That Make Carbon

Why have Carbon Farmers recorded such outrageously high rates of soil carbon sequestration compared to the small amounts that official science has recorded in our poor, degraded soils. Only one word can explain it: "Biology". Actually, "Microbiology". You can call them "Microbes". Scientists call them "Soil Bota". Most of them smaller than the eye can see, all of them hidden from view most of the time in the soil, the bactera and fungi, nematodes and protozoa, mites and micro-arthropods, ants and termites, and the earthworms all live together in 'communities'. They either eat each other or help each other do their work, tending to the roots of plants and helping them to grow. And it is the way the land manager caters to these miracle workers of the underground that determines the performance of the soil.

Everything we do as land managers translates into some effect in the microbes' working conditions and hence their morale. If they are satisfied with their conditions, they will work like navvies to turn out big, healthy, robust plants. If not, you may not get anything but bare earth. (Weeds, by the way, are evidence that microbes are present and working. But they lack proper nutrition, as the weeds are trying to repair the soil.)[17]

Carbon Farmers are not talking through their hats when they report increases up to 1% and 2% in total carbon in a decade. These are the results of tests conducted by NATA-registered scientific laboratories. No scientist can believe these results because they run so counter to their expectations. Nothing they have ever experienced came near to these scores. No previous research had indictated that 'land management' could make such a difference. But no previous research had focussed on land management as a variable. The soil research done as part of the National Carbon Accounting System – a report prepared to on the nation's carbon emissions as part of the Kyoto Protocols – found an anomaly which pointed towards the possibility that land management could be important. The soil health of 'paired sites' (adjacent paddocks with different management histories which can be compared) was measured by sampling. The researchers caught a glimpse of what now know

[17] Weeds are our friends, according to my friend Peter Andrews, (the "Water Method Man"). Weeds usually grow in places that need protection, like bare earth or erosion points on the banks of waterways (blackberries are good for stablising and keeping animals off weak spots). Those with tap roots are useful n bringing minerals to the surface where they are needed. Allan Savory calls weeds "herbaceous forbs"

today is possible: that a well-managed graging operation can sequester more carbon than a similar piece of land still unclear under native vegetation.

"The data show that there may be some sites where the differences in carbon density between cleared and uncleared land may be as low as 5 t/ha[18]. Further investigation of these uncleared sites is required to establish the reason for this result. Grazing history and the history of grass growth are two obvious avenues to investigate" says Dr Brian Murphy. The species pattern they observed is a classic case of "Succession", which is a natural process by which land managers can observe the soil as it moves through the various stages of lichens, mosses, and algae (early colonizers), small hardy shrubs, broardleaf weeds, lower order grasses, native perennials, forbs, and native trees. At each stage, both the vegetation and the biological community become more complex and biodiverse. A case in point: Matt Carter of "Myall Springs" near Gunnedah NSW started planned grazing in 1997 and now has pasture dense with native grasses, legumes and herbs that his father cannot remember ever seeing on the property. Paddocks that were previously dominated by wire grass, slender bamboo and saffron thistle, are now thick with danthonia, plains grass, red grass, kangaroo grass, barbed wire grass, and solky brown top. A survey found 50 species of native grasses, legumes and herbs in an area of 10 square metres. His production levels have grown The Murphy team reported: "A review of the grass species at the uncleared sites … shows that two of the sites having high carbon density levels of about 40 t/ha had a wide range of grass species present with several being dominant. The species present were also those considered to be more productive including Kangaroo Grass, Danthonias, and Curly Windmill Grass. Those with lower soil carbon densities were those with the spear grasses and wire grasses."

"Land management" means more than simply managing land. In Carbon Farming, "land management" refers to specific actions that aim to rebuild soil health, unlike "land management" in the past that led to soil degradation and erosion, the results of heavy tillage, overstocking, and indiscriminant use of herbicides and pesticides...

Putting Microbes To Work

The land management methods Carbon Farmers use are different because they put the Microbes to

[18] On average, between 10 t/ha and 25 t/ha soil carbon was lost when native vegetation was cleared. Brian Murphy, Andrew Rawson,, Loren Ravenscroft, Madeleine Rankin and Russell Millard, Technical Report 34. Paired Site Sampling for Soil Carbon Estimation – NSW, National Carbon Accounting System Australian Greenhouse Office, 2005.

work by equipping them and motivating them. Microbe-friendly Carbon Farming Land Management has at least one of the following techniques or more likely a combination at work together:

• grazing systems (such as time controlled grazing) which use the animals to till and fertilise the soil;

• new cropping systems (such as no-till or pasture cropping) that leave the soil undisturbed so that it retains moisture and nutrients;

• new organic fertilisers and composts that give the soil back much of the organic matter that had been taken by animals and harvesters;

• a new generation of 'soil treatments' including biochar, compost teas, and probiotics, exotic solutions that are yet to be officially recognised by science.

> **"Decomposition is the essential and fundamental counterpart to the ecosystem function of photosynthesis."**[1]

None of these techniques were developed to capture and store carbon. They were all designed by their 'inventors' to restore the soil to health. "Soil Health" is still the main game for many people using these techniques. But they are also the same techniques needed for growing the soil carbon. The two processes are firmly hooked together.

For a long time the Microbes toiled on without much applause or recognition. Farmers knew they were getting results. The connection was not made between the land management technique and what happened down under to create richer, healthier soil that held more water and also had a higher soil carbon reading. That secret ingredient is now recognised as the microbial communities that live and work in the soil, managing the nutrient process and giving the plants what they need.

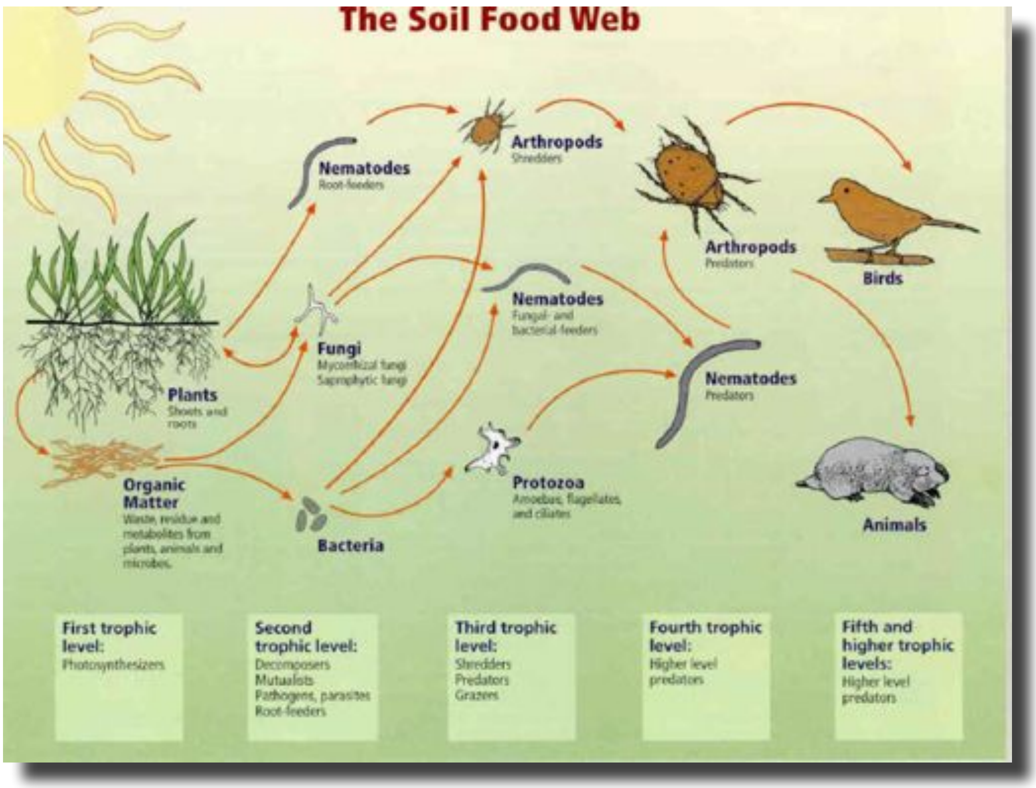
Even Allan Savory, the pioneer of systems thinking in agricultural resource management, mentions 'soil organisms' twice in his game-changing book Holistic Management. He gives the microbes a key role in soil aeration, organic material management, and drainage, and also recognises their role in the mineral cycle. But he was at the same disadvantage today's scientists and agronomists find themselves suffering – lack of knowledge of soil biology.

It is now widely agreed that soil biology education and research has been neglected. In fact, in the last 10-15 years the entire field of soil science has been defunded in this country. Courses have been closed; student numbers falling. Despite all the words of politicians about the importance of restoring our natural resource base, soil has been through a long drought. Water and forest interests and the fashionable science of "ecology" have dominated the debate and the budgets. Within Soil Science itself, the discipline has been dominated in Australia and overseas by physicists and chemists.

The enthusiasm for soil biology among farmers is not new. In 2004, the organisers of a soil biology workshop at Tamworth NSW had to turn farmers away. It was organised by the NSW Department of Primary Industries and the Grain Research and Development Corporation's soil biology initiative.

Some "Biological Farmers" were conscious of the role microbes play. But most concentrated on getting the chemistry right, using natural products. The surprise is that Biodynamics, which sees the plants in the soil influenced by their "astral and etheric" being, in turn this is influenced by the movement of the sun, moon and stars. But he founder of this mystical form of land management gives soil organisms little to do in the grand scheme. They merely indicate by their presence that other essential processes are happening, according to the mystic Steiner.

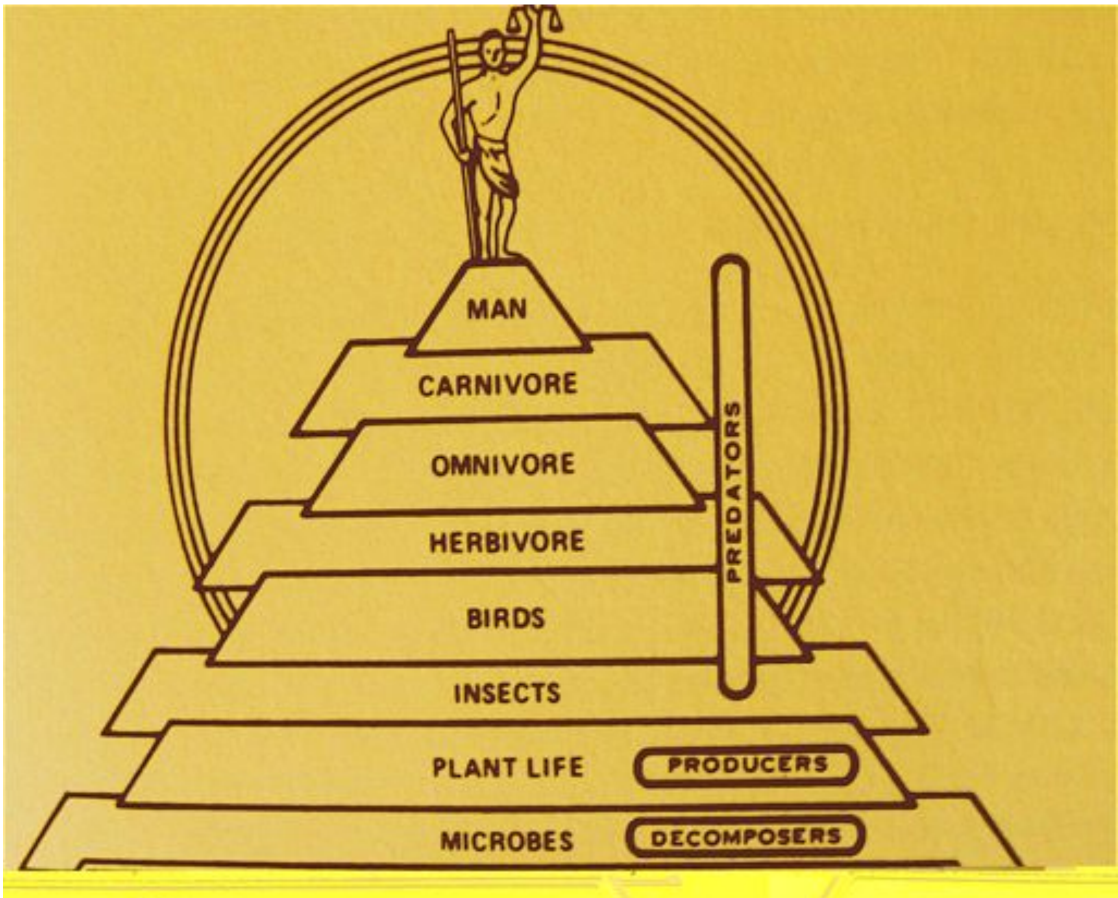
The lone voice promoting the contribution and importance of soil microbes has been American researcher Dr Elaine Ingham who introduced the concept of the "Soil Food Web" which links the world below with the world above the soil, via a series of relationships between species. She also taught many land managers to identify their microbial partners and provide for them.



The Soil Food Web

A "Soil Food Web" is just what the name says it is: a web of food sources and food consumers and they are in or of the soil. And all the parts are living. It is a tangle of food chains. If you add the physical, non-living environment that the living creatures interact with, you have an ecosystem. This is the basic unit of an ecology.

Food webs transfer energy from plants through Plant-Eating Animals (herbivores) to Animal-Eating Animals (carnivores) and Those Who Eat Both (omnivores), and ultimately to the Creatures That Eat Dead Organic Matter (detritivores) and Those Who Break Down Dead Tissue (decomposers) that enrich the soil with organic waste. Therefore the Soil Food Web is the channel for the Process of Birth and Growing that we call Photosynthesis can operate. But it is also a channel by which The Process of Death and Renewal called Decomposition operates. *To understand how the process fits together, follow the energy trail: All the creatures in a biological community share the need to obtain energy from food. The Sun sends energy to Earth in the form of electromagnetic radiation. Plants convert this into chemical energy in the form of carbon, through the process of photo-synthesis.*



Albrecht's Biotic Pyramid

Herbivores eat the plants and are eaten by carniovores or omnivores. Everyone dies and is eaten. No one feeds unless it's on another. And in the world of agriculture the microbes sit down at the table first, according to Dr William Albrecht, the legendary American soil scientist who defied "Industrial Agriculture" and its overuse of artificial chemicals. He saw the microbes as not to be feared, as 'germs', but to be protected and employed for the good of mankind. "Microbes are a foundational part of the pyramid of life forms, of which we are the topmost…. [Microbes] are next to the soil in that pyramid structure. They are between the soil and the plants…"

"The microbes are the first crop we grow each spring," he said. They compete with plants for nutrition if there is not enough organic matter left for them. But they are the biggest eaters in the world. They've got to eat so we get to eat.

Enter the Decomposers

Detritivores are the first line of feeders on living things that die. For instance, maggots, eat what's left of formerly living things, breaking organic material down into inorganic substances. Their internal systems process compounds containing the carbon and release that carbon into the atmosphere and soil in such a way that what remains is material that enriches the soil to stimulate the growth of new plants. Detritivores pass the ball to the Decomposers, a group which has the largest number of organisms in the soil food web. Billions and billions, can fit inside a matchbox. The Decomposers break down the nutrients in decayed organic matter far more than do Detritivores.

Typically, decomposers are micro-organisms, including bacteria and fungi, and they process materials in such a way that complex compounds undergo the chemical reaction of decomposition. Through decomp-osition, compounds are broken down into simpler forms, or even into their constituent elements, which provide the environment with nutrients necessary to the growth of more plant life.

Microbes: Storehouses of Nutrients

In a healthy Soil Food Web, vast amounts of nutrients that plants can use are stored in the bodies of the bacteria and fungus and the other microbial creatures. There can be tonnes of microbes per hectare. Bacteria makes up the most of them, and they contain a higher concentration of nitrogen than any other creature on the planet. Fungi come second in that race. They also carry huge amounts of phosporus, potassium, sulfur, magnesium, calcium and many other elements.

Bacteria and fungi do most of the important work of de-composition, eating tonnes of decomposing matter daily and storing it in their own bodies. They play an important role in immobilising nutrients and storing them in soil. They are also important for nutrient cycling.

Nutrient cycling happens when other creatures consume bacteria and fungi. They are eaten by protozoa, nematodes, micro arthropods and worms. In fact, between 40% and 80% of the nitrogen made available to plants is released when protozoa eat bacteria. The bacteria can 'fix' nitrogen by absorbing it from the atmosphere and converting it into forms that plants can use.

Cities Beneath Our Feet

The key to understanding the value of the soil microbe is to understand their habitat. Then you will know how you should act towards them, in ways such as providing them with food and water and protecting them from disturbance.

Soil organisms inhabit the spaces inside and between soil particles because they can. A bacteria is about 1 micron or 1/1000thmm. You need a microscope to see most of the creatures down there. Not only is it a tiny world, it is also very diverse. You would only have to travel a short distance to experience vast differences in pH, moisture, pore size, and the types of food available. This creates a broad range of habitats.

At the bottom of the feeding chain are bacteria and fungi. They need something to feed upon, and Nature usually supplies them with organic matter such as dead vegetation and animals. Now we have to supply them with crop residues or a covering of litter. If we fail to provide food for the Soil

Food Web, the population of the community will decline to a point where the society in the soil collapses and the soil becomes officially ‘dead’. Thereafter it becomes a medium for holding the plants up and transferring to their roots the manufactured fertilizers and biocides.

We must also provide shelter. Bare earth, baked by the Sun, is no place for a microbial community. They prefer a “litter roof” or mulch that shades their soil and helps it retain moisture. Beneath the ‘litter roof’ is a truly astounding transportation network; an underground society with cities and highways and tunnels that carry air and water. Earthworms bore large tunnels and coat their walls with a sticky substance to seal it. These become aquaducts when it rains. A healthy soil should be close to 50% space for these purposes, 45% mineral and ideally 5% organic matter. (This is an ideal.)

To protect the habitat, land managers have several options:

1. Minimum soil disturbance (The complete non-disturbance of soil is a point of debate between organic, subsoiling, and carbon farmers. Organic farmers do disturb the soil deeply at times. Subsoilers use a “Yeoman’s Plough” which has a thin tyne and a paddle at the bottom to lift the soil and drop it up to 50cm deep. Carbon farmers

tend to avoid disturbance because of the emissions of methane and CO_2 it causes.)
2. Maintenance of soil cover (Biomass is ideal for mulch. But in some societies they use crushed concrete, etc. because demand for biomass is high.)
3. Crop rotation and cover cropping (Pasture cropping and perennial cover cropping allow the grain producer and the grazier alike to enjoy the benefits of the vigorous growth that species diversity stimulates – ie. all species of plant seem to grow more prolifically when an other species is growing within proximity of its rhisosphere. This explains the 'edge effect' when two crops are grown side by side. Strip cropping – a method whereby two crops grow on alternating strips – is designed to take advantage of this effect.)
4. Avoid excessive pesticide or herbicide use (Even small amounts of poision can destroy microbial communities.)

Reasons for putting away the plough include:
1. Loss of Soil Organic Matter (SOM) when vast amounts of oxygen are infused in the soil, resulting in rapid decomposition of SOM.
2. Slicing through the networks of fungi rapidly converts the soil into a bacteria-dominant environment.
3. Ploughing damages the soil structure which reduces the arthropod and earthworm numbers.
4. Mouldboard ploughing readily forms a hard pan or a layer of compacted earth that blocks root growth and makes a barrier to prevent water and oxygen reaching the lower levels.

The Root of the Matter

The rhisosphere (the area around the roots of a plant) has been called the next big frontier in farming. "Roots are the best way to influence soil biology to enhance farming systems," says Michelle Watt, CSIRO Plant Industry. The three main reasons for this are that:
1. Roots are the largest component of the soil biology, including the living roots of the crop and the dead roots from previous crops.
2. Roots are the source of almost all the below-ground carbon that feeds organisms such as bacteria, fungi, protozoa, nematodes, ants and termites.
3. Roots create soil spaces for future roots and organisms, and aggregate soil particles with their root hairs and special glues. The size of the soil spaces influence water movement and its availability to the crop."

The root zone is where all the dramatic action takes place in the world of soil micro-organisms. Up to 90% of a soil's metabolism comes from the activity of microbes and protozoa. Around 95% of the soil respiration (emitting CO2) has got nothing to do with plants. It is released by soil microbes.

Root Zone: Where magic happens

The most dynamic and exciting zone of the universe that exists below the ground is the 1mm of soil surrounding a plant root: the Rhizosphere. It is the scene of intense biological and chemical activity, driven by compounds exuded by the root system and by microorganisms feeding on these compounds.

As roots grow they release water soluble compounds - amino acids, organic acids, carbohydrates, sugars, vitamins, mucilage and proteins – that supply food for the microorganisms. In turn, these microorganisms provide nutrients for the plant. Exudates help roots adsorb and store ions for plant use. For instance, flavonoids in legume roots activate genes responsible for root nodules that allow the plant roots to obtain nitrogen from the air. Exudates can transfers to the rhizosphere up to 20% of all carbon created by the plant via photosynthesis. They may also encourage vesicular arbuscular mycorrhizae that colonise roots and send out miles of thread-like hyphae into the soil, increasing the surface area and distance covered by the roots and taking up nutrients for the plant.

Exudates stabilise soil aggregates around the roots. Sticky mucilage secreted from continuously growing root cap cells can alter soil. Rhizosphere soil is wetter than other soil: exudates protect roots from drying out. Exudates released at night allow expansion of roots into the soil. At dawn, the process reverses. Waste products and secretions from microorganisms attracted by exudates help combine soil particles into stable aggregates around plant roots. These aggregates hold moisture.

The root 'exudates' also act as messengers between roots and soil organisms. Root cells are under continual attack from Micro-organisms. They survive by secreting defence proteins and other antimicrobial chemicals. By influencing microbial activity and population numbers, they can affect other soil organisms. They can attract and repel particular microbe species and populations.
Exudates also assist plants to inhibit

the growth of competing plant species. Plant roots are in continual communication with surrounding root systems and quickly recognise and prevent the presence of invading roots through chemical messenger exudates.

The rhizosphere is like the wild west, a panorama of intense biological activity due to all the food provided by the exudates. Competing constantly for water, food and space in the root zone are bacteria, actinomycetes, fungi, protozoa, moulds, algae, nematodes, earthworms, millipedes, centipedes, insects, mites, snails, small animals and soil viruses. Many microorganisms have relationships with plant roots. These can be symbiotic (benefit their growth) or saprophytic (live on dead roots and plants). Rhizosphere microorganisms produce vitamins, antibiotics, plant hormones and communication molecules that encourage plant growth. Some also attack and kill plants.

Exudates from roots also play a key role in making soil carbon, by a process called ‘rhizodeposition’.

Bacteria

Bacteria are essential elements for life on Earth. They decompose organic material to make it available to plant nourishment. They recycle natural elements that would otherwise be bound up in the soil. They also control the amount of carbon dioxide in the atmosphere; ninety percent of carbon dioxide produced on Earth from natural processes comes from the activity of bacteria and fungi.

Bacteria are the most prolific creatures in soil: Up to 5,000 species can be present in one gram of soil. The mass of soil bacteria can be 9 times as great as the combined mass of fungi, protozoa and nematodes. They can be found teeming around the roots of plants.

Two types give nutrients to plants: heterotrophic bacteria and auto-trophic bacteria. Heterotrophic bacteria break down organic matter into nutrients the plant use to make photosynthesis happen. Autotrophic bacteria create their own organic matter from carbon dioxide. They also break down other organic materials. The autotrophs obtain their energy from sunlight or the oxidation of inorganic substances such as ammonium, sulfur, and iron and most of their carbon from carbon dioxide.

Bacteria are central to nitrogen fixation, the combination of atmospheric nitrogen with hydrogen to form organic nitrogen compounds usable by higher plants. The process can be carried out by bacteria in soils independent of plants, but the amount of nitrogen fixed is much greater if the bacteria are intimately associated with plant roots.Two species infest and form nitrogen fixing nodules on the roots of the legume family which includes many economically important crop, forage and pasture plants. Cyanobacteria (blue-green algae) contain chlorophyll and can photosynthesise. Which is why large amounts of atmospheric N are fixed by them.

Fungi

Fungi are everywhere. Science hasn't identified the vast number of species. Fungi can be immense and ancient. One, that covered 1,500 acres, was estimated to be more than 1,000 years old. They play a dramatic role in the process of creating carbon. Soil fungi

grow long threadlike fingers called hyphae that make a tangled mass called mycelium. The mycelium absorbs nutrients from roots, surface organic matter or the soil. They play an important role inmmobilising and retaining nutrients in the soil by consuming the nutrients in the organic matter. They can breakdown cellulose, proteins and lignin. Fungi consume complex compounds, such as fibrous plant residues, wood, while bacteria tend to use simpler compounds, eg. root exudates or fresh plant residue. Fungi are found wherever there is hard, carbon-rich woody organic matter.

Decomposers or saprophytic fungi convert dead organic matter into their own bodies, carbon dioxide and acids

Symbiotic Mycorrhiza fungi grow inside plant root, obtain sugars from a plant, the fungi then extends the plant root system, up to 15 cm from the root, and provides up to 10 times more surface that helps uptake of nutrients that are immobile and in low concentrations, especially phosph-orous. Some fungi are pathogenic. (Bad news for plants.) But soils with high biodiversity have been shown to suppress soil-borne fungal diseases Hyphae bind soil particles together to create aggregates which make the pore spaces in the soil that improve water retention and drainage. Mycorrhizal fungi are found in all soils. Fungi can survive in the soil for long periods even through periods of drought by living in dead plant roots and/or as spores or fragments of hyphae. Tillage physically severs the hyphae and breaks up the mycelium. Mycorrhiza increase under pasture because pasture includes highly mycorrhizal plants such as grasses and legumes. Fungi numbers reduce under wheat, canola and lupin. Mycorrhiza also play a role in stabilising soil aggregate structure and in enhancing nodulation and N fixation by legumes.

Actinomycetes

Actinomycetes are bacteria that resemble types of fungi that form hyphal mycelia. They breakdown tough compounds such as chitin and cellulose. They are involved in forming stable crumb structure. They assist in reduction of plant pathogen suppression by prod-ucing antibiotics. They also give soil its earthy smell.

Actinomycetes are the source of antibiotics such as actinomycin, tetracycline, and neomycin. They are called "nitrogen fixers" because they convert atmospheric nitrogen into a form that can be used by plants.

Algae

We all know that algae live in waterways. But they are also live in soils. As pioneer species, they contribute to building soil. Algae photosynthesize energy from sunlight and deliver large amounts of organic matter to the soil. They produce substantial organic matter in some fertile soils. Some algae excrete polysaccharides which increase soil aggregation

Algae can also make nitrogen available to plants. The sticky organic "stuff" that algae brings to the soil improves soil quality because it and contributes to making soil porous. Algae enables lichens to colonize the harshest environments, even when there are little nutrients, water, and warmth. Fungi and algae get together to make it possible.

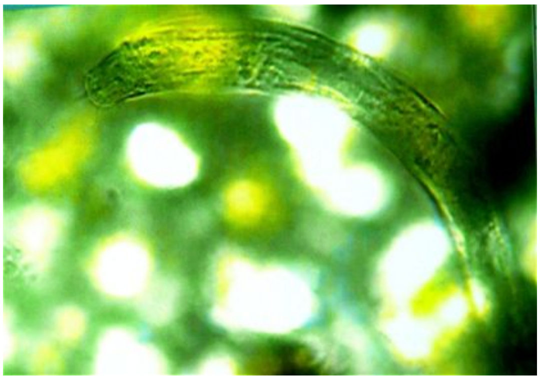
The algae produces nutrients by the process of photosynthesis and the fungus provides inorganic nutrients sourced from the soil which the lichen needs for growth.

Protozoa

Protozoa, one-celled creatures found in moist soils, control the populations of bacteria, by eating them. There are two types, named for the way they move: one called "flagella" (whips) because they can move by a whipping motion; or cilia (circular shapes moving with little hairs). Or they can be like amoeba and morphing constantly changing in shape.

Single celled protozoa are the most varied, numerous and simplest form of animal life. More than 250 species have been isolated in soils, sometimes as many as 40 or 50 of such groups occur in a single sample of soil. They generally thrive best in moist well-drained soils and are most numerous in surface horizons, the biomass ranging from 20 to 200 kg/ha.

Nematodes



Nematodes are one of the world's most prolific species. Dr. N.A. Cobb wrote in 1914: *"If all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable....We should still find its mountains, hills, vales, rivers, lakes, and oceans, represented by a film of nematodes."*

Normally invisible, unsegmented roundworms, commonly called threadworms or eelworms, found in almost all soils, often in very large numbers and great diversity, Nematodes are predators in the soil; they control bacterial population, as well as fungi, protozoa, and other organisms. Nematodes, in turn, are eaten by fungi. Some nemotodes (saprophyitic) are decomposers – break down organic matter, release nutrients, and improve soil structure and water holding ability. Some (parasitic) do damage to root systems and slow growth by allowing fungal rot to invade them. Cultivation encourages the parasitic species. Nematodes release nitrogen stored in the bodies of bacteria and fungi. Nematodes also give fungi and bacteria 'a ride' around the root zone, helping them disperse throughout the soil. Nematodes need a source of organic matter. They dislike pesticides. The state of the nematodes in the soil can be a useful indicator for the condition of the soil food web – whether it is disturbed, maturing, structured or degraded.

Termites

Termites eat dead plant material. They can digest molecules used to build plant cell walls: cellulose and lignin. They are great tunnellers, with the deepest reported tunnels 80 m deep (Kimberley region, WA). They humify the soil and several species have been shown to increase soil nutrients 2-7 times, in north Queensland and south west WA. Termites are valuable in arid landscapes, maintaining higher plant growth in patches. Increased water capture and rapid nutrient cycling as well as nitrogen fixation are services provided by the termites in vegetation patches. These services are essential in restoring a degraded semi-arid landscape before plants are established. Termites can improve agricultural soils in low, zero and conservation tillage. Their tunnels are conduits into the soil for surface water, especially rain. Termites also carry water in little internal sacks to different forage sites Termites carrying nitrogen-fixing symbio-tic microflora have been known to be more active during drought.

Ants

Australia has more diversity and more numbers of ants per head of population than most other nations. In arid Australia there can be 100 species in a single hectare. Ants nesting and boring activities improve water infiltration and the movement of nutrients through the soil. Inland regions can have up to 80,000 nest entrances per hectare. Water infiltration with nest entrances has been recorded at 23 mm/minute vs 5.9mm/minute without entrances.

Earthworms

Earthworms create soil quality by converting organic matter into humus. Their castings are richer than the surrounding soil. They excrete calcium carbonate which lowers soil acidity. Earthworm castings are rich in all the growth minerals necessary for plants, in a water soluble form immediately available for plant use. They contain more calcium, nitrogen, phosphate, and potassium than other soil. Their burrowing helps to loosen and aerate the soil. All the soil you have ever seen has passed through the stomachs of numerous earthworms to become what it is. Earthworms can shift stones 60 times their own weight
Their numbers vary widely in different soils, In arable soils they may range from 30-300 per square metre, with a biomass of 110-1100 kg/ha. They prefer a well aerated, moist habitat such as medium-textured well-drained soils. Their numbers decrease because of predators, ammonia fertilisers, most insect-icides and soil disturbance through tillage.

Minimum tillage leaves residues that earthworms like. Earthworms grind up organic matter and minerals, and eject soil casts which are higher in bacteria, organic matter and plant nutrients. Their burrows, up to 1-2 metres deep, serves to increase aeration and drainage. They enhance soil fertility and productivity through increasing availability of mineral

nutrients to plants and integrating undecomposed surface residues, into the soil, hence reducing loss of nutrients, increasing O.M. content and improving soil structure. In one year in one hectare of land, earthworms may ingest between (22 to 450 tons/acre). They rely on organic matter as a source of food and thrive where farm manure or plant residues have been added to the soil. Populations of earth worms flourish when farmers give up the plow. Earthworms have been known to offset soil degradation through such means as deep burial of lime to reduce acidity. Some species maintain permanent burrows that allow water to penetrate 2 to 10 times faster, even through clay.

Rhizodeposition: the Hole in the Bucket

The Official Theory of Soil Carbon Sequestration holds that Carbon levels can ONLY be increased by the addition of Organic Matter. The amount of organic carbon in soil is determined by inputs of dead plant and animal material. This theory limits the amount of carbon a soil can sequester to a theoretical ceiling of biomass introduced into the soil. It is called the Bucket Theory because you can only get out of the bucket what you put in. This theory overlooks critical aspects of microbiology of soils. During their life, plant roots release organic compounds into their surrounding environment. This process, named rhizodeposition, is of importance because it is an 'input flux' for the organic Carbon pool of the soil. Results from tracer studies (43 articles) show that, on average, 17% of the net Carbon created by photosynthesis is exuded by roots.19 In another study, the simulated percentages of rhizodeposition in the total net C

[19] Christophe Nguyen, Rhizodeposition of organic C by plants: mechanisms and controls, Agronomie 23 (2003) 375-396

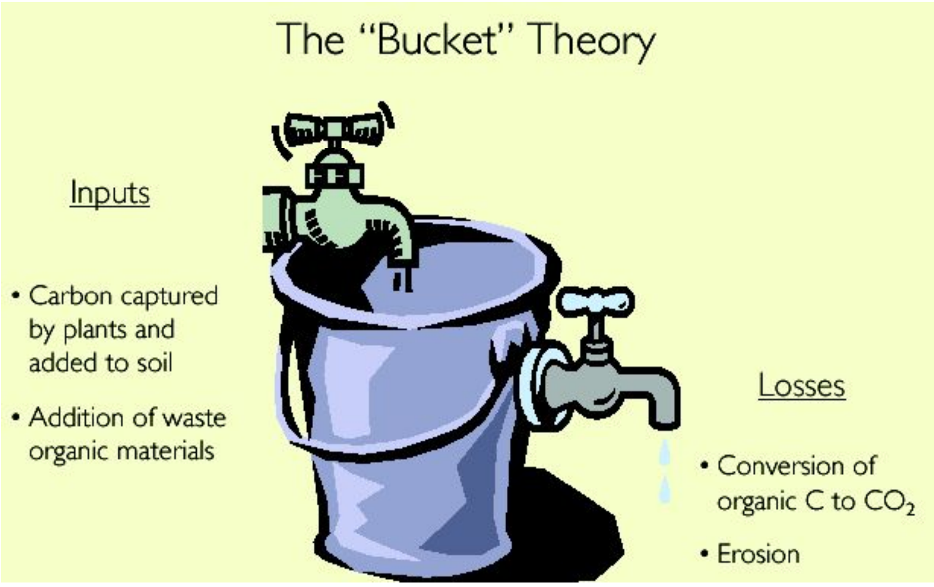
fixed photosynthetically (above-plus below-ground production) was 24.4%, of the total CO2-C fixed. Experimental estimates ranged from 7 to 48% relative to the Carbon fixed photosynthetically. The simulation gave a root-plus-rhizodeposition production equal to 1.8 that of stalk plus leaves, corroborating that corn may translocate more to the soil from below- than above-ground.[20] Deposition of carbon in soil from root exudates is not recognized by the Roth C Model which dictates what levels of soil carbon can be stored in Australia.

Photosynthetic Microbes: There is a class of microbial life called 'autotrophic' or 'phototrophic' that do not rely on Organic Matter for their sustenance. They use solar energy to grow via the process of photosynthesis. Cyanobacteria and Algae are examples. These add Carbon independently of other processes.

[20] J.A.E. Molinaa, C.E. Clapp, D.R. Linden, R.R. Allmaras, M.F. Layese, R.H. Dowdy, H.H. Cheng, Modeling the incorporation of corn (Zea mays L.) carbon from roots and rhizodeposition into soil organic matter, Soil Biology & Biochemistry 33 (2001) 83-92

Autotrophic bacteria obtain their energy from sunlight (by photosynthesis) or the oxidation of ammonium, sulfur, and iron. They get their carbon from carbon dioxide.

- phototrophic cyanobacteria
- green sulfur-bacteria
- some purple bacteria
- many chemolithotrophic species, such as nitrifying or sulfur-oxidising bacteria.[21] Many species of algae live in soils and photosynthesise their carbon as plants do.



The Bucket Theory is simplistic and inadequate. It doesn't accord with science and it doesn't reflect farmer experience.

[21] Hellingwerf K, Crelaard W, Hoff W, Matthijs H, Mur L, van Rotterdam B (1994)."Photobiology of bacteria". Antonie Van Leeuwenhoek 65 (4): 33147. doi:10.1007/BF00872217. PMID 7 832590.

The Liquid Carbon Pathway

The Carbon Pathway is the link between the CO_2 captured by plants and the soil where much of the Carbon is stored as humus. Dr Christine Jones described how the process works when she, Tim Wiley (WA DAF) and Bob Wilson (Evergreen Farming) appeared before a Senate Committee to testify about agriculture and climate change.[22]

Dr Jones—There is a carbon pathway from gas, as carbon dioxide has to be fixed in leaves as glucose, which is liquid. It goes through the plant and then, to come out of the roots, you have to have microbial associations around the roots that then take that into the soil, in particular, mycorrhiza that use that carbon. They can use 60 per cent of the carbon that is fixed in the green leaves, and 80 per cent that can be turned into humus, so it is a huge equation, a huge, huge amount of carbon that can be fixed. That is why we are seeing the sequestration levels that we are seeing. Also, it is carbon that is not then subject to oxidation, so it does not break down and go back to the atmosphere. But if you knock out those microbes that are part of that pathway, it does not happen. If you use herbicides and if you use conventional fertilisers, you kill the microbes in the soil that are the endpoint of the pathway. What happens in a conventional zero-till type cropping is you would have stubble that would break down into the soil and form what they call labile carbon, which is very readily decomposed, and within 12 to 18 months most of that goes back to the atmosphere as carbon dioxide. So it is a very rapid cycling of carbon, and the reason that that happens is that the microbes necessary for humification are not there because the chemicals used in zero till have knocked them out

[22] Hansard, SENATE STANDING COMMITTEE ON RURAL AND REGIONAL AFFAIRS AND TRANSPORT, Climate change and the Australian agricultural sector, MONDAY, 30 JUNE 2008

of the system. This is why we have experts across Australia telling us we cannot build soil carbon because they are looking at conventional zero-till systems where the microbes that you need to build the carbon simply are not there. They are actually quite correct that you cannot build carbon in those systems. But if we go to perennial based agriculture and change the soil biology and get the microbial associations, we can build carbon at rates faster than people will actually acknowledge is possible. The Australian Soil Carbon Accreditation Scheme was established to measure those levels so that we can say this is happening and use rigorous science to measure that and record that...

When we measured the nutrient levels in his paddock this year prior to him sowing his crop, the phosphorous levels had gone up by a factor of five. The agronomist actually thought there was a laboratory error in the data. We relooked at that and at bare areas compared with areas under the grass, and it was correct that available phosphorous had gone up by a factor of five.

Senator HEFFERNAN—And that is the microbes releasing it.

Dr Jones—Yes. Phosphorous fertilisers had been used over time, under 15 years of zero till in that area, and they just formed a phosphorous bank that had been inaccessible. A fortune has been spent on phosphorous fertilisers. That farmer will not need to apply phosphorous fertiliser, we do not know for how long but for several decades, because the microbes are releasing what has been built up. You mentioned before the issue with your conventional zero till and why it is that carbon does not work, nitrogen does not work and phosphorous does not work. Nothing works because you have to have a microbial bridge between plants and minerals in the soil. Plants cannot actually access those unless that is in place. Normally the carbon from plants feed the microbes that in turn bring nutrients back to the plants. We have destroyed all those associations in soil by loading it with toxic chemicals, basically. What has been in favour of its adoption is not only climate change but the rapidly increasing price of phosphorous, nitrogen and herbicides. That has encouraged farmers to look for alternatives to that system.

Senator MILNE—
Congratulations for realising that we need a radical shift and not just incremental change…. I am particularly interested in the research you have been doing and any connection with CSIRO, the Bureau of Rural Sciences, Land and Water Australia or anyone anywhere in the research body across Australia in looking at the potential of building

resilience in soils as an adaptation strategy to climate change and maintaining food security. Is CSIRO actually looking at this in any way? Is anyone supporting you in developing field trials across the country and in helping to get the data together—doing all that—or are you battling on your own?

Mr Wiley—What we are talking about is radical.

Senator MILNE—Yes, it is a radical shift.

Mr Wiley—For me, it has been driven from the farmers' paddocks… These things really are off the scale of what was thought possible. What we have been saying has been very contentious in the scientific community. But I do believe that, probably only in the last 12 months, there has a considerable change in attitude and there is now real interest. We are certainly starting to talk to people in CSIRO… We are in the middle of a significant change in thinking. It has already happened for our farmers in the north but I am not sure if the rest of Western Australia believes that this is real and that we are going to get dinkum. … There is a lot further to go and we do have the problem that we have very limited data that does not stand up to detailed scientific rigour… We actually need to get that data and we need those scientists involved. They need the funds to be able to do it properly.

Senator MILNE—Do you want to comment on this, Dr Jones?

Dr Jones—My comment would be that I have been applying for funding for this for 10 years at least. I have folders full of reject letters saying that it was an extremely well worded application, that it has possibility but the current science does not support it and it is not possible to actually increase carbon to the levels that we were documenting on farm. I would have to say that that has changed very quickly recently. In fact in the last week even, there have been huge changes. I think we have just finally got to the tipping point. We have 2,000 farmers involved in this. It is a huge grassroots revolution that the scientific establishment for some reason seems to be completely unaware of or, if they are aware of it, have totally discounted as irrelevant.

I travelled to Central Queensland last week with a professor from the University of New England, where I formerly worked. He is the head of the beef CRC and a professor of meat science. He was going there to talk about tenderness in beef. He does not get to interact with farmers because he goes to conferences and talks to people at that level. Over 200 farmers came to this workshop and they got up and talked about and gave presentations on pasture cropping and presented their data with very professional PowerPoint presentations. They have data, but it is considered anecdotal because it does not fit into the scientific model. The professor was blown away. All he could talk about was what he had seen that day and this farmer revolution. He said, 'How come I have never heard about this?' The scientific establishment have been talking among themselves and, out there, farmers all over Australia are doing this other amazingly innovative stuff. Now, all of a sudden, this bubble here seems to have burst and we are getting through. DAFF are now very interested in what we are dong and suggesting that if we talk to them and give them some case studies then they might be able to provide some funding. I think we are going to see an explosion in this area. I am feeling very positive as of last week, I would have to say.

Senator MILNE—What sort of formal interaction are you having with Dr Geoff Baldock and the CSIRO in Adelaide on soil carbon?

Mr Wiley—Jeff has heard of some of these figures and what he has done is run it backwards through the Roth C model. He has run it back and said, 'You would need to be growing 30 tonnes of dry matter per hectare per year to get that level of sequestration; you cannot do it,' and we would agree entirely—we cannot. So our data is not fitting with his model. Either our data is wrong or his model needs readjusting. Basically [he said] if this is real [he] will go and change the model to fit what is actually happening in the paddock. That is what we have lacked, good hard data, and that is what we are trying to get right at the moment—but it will still be limited—so that they can make the model fit what is actually happening in the paddock... Getting the model right is absolutely critical for Australia... But we will need a very large investment to get those models right so they are reliable.

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"The complexity of large agricultural systems encourages a reductionist approach to study and management that precludes observation of largescale effects."

Robert L. Zimdahl, Agriculture's Ethical Horizon

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Carbon Farming: Grassroots Innovation

Trading in Soil Carbon Credits could soon be law in Australia, thanks to the scientific vision of Dr Christine Jones.

The Carbon Farming Initiative first saw the light in August 2010, almost exactly 5 years after her first Managing the Carbon Cycle Forum, where Christine Jones lit the wick to the powder keg now known as the soil carbon movement. Shortly afterwards, at a YLAD Living Soils seminar she announced: "If financial incentives in the form of 'carbon credits' amounting to several thousand dollars per hectare became the primary focus of primary production, farm enterprises such as meat, wool or grain could become of secondary importance as an income source. This would reduce the potential for destructive farm practices and provide a large incentive for 'greener' forms of agriculture."

She identified the opportunity that has driven the soil carbon campaign ever since: "Appropriately managed farm-lands could effectively 'mop up' most of the excess carbon being emitted to the atmosphere, converting a potential hazard into an extremely productive opport-unity."

Always the pioneer, Dr Jones even calculated a value for soil carbon. "Sequestered carbon is a tradeable commodity. It has different values in different markets and the price is subject to market fluctuation." For example, a 1% increase in organic carbon in the top 20 cm of soil with a bulk density of 1.2 g/cm^3 represents a 24 t/ha increase in soil organic carbon which equates to 88 t/ha of CO_2 sequestered. "If the CO_2 equivalent in the above example was worth $15/t, the value of sequestered soil carbon in 'carbon credits' would be $1,056/ha." These amounts appear at first glance outrageous. But the calculations are bas ed on the same formula used by conventional scientists to convert carbon percentages into tonnages at different bulk densities. What could have appeared to be outrageous at the time was th e rate of sequestration: "These levels of increase in soil carbon are achievable, and have already been achieved, by landholders practicing regenerative cropping and grazing practices.." Impossible, said official science, soil carbon grows by minute amounts, if at all in Australia. But official science had yet to study carbon farmers who commonly report 2% increases in soil C over the driest, hottest decade on record. Dr Jones's most recent research at Col Seis's property "Wyona" found a sequestration rate of 33 tonnes of CO_2 per hectare per year (2008-2010). At a carbon price of $20 per tonne, and assuming payment for non-labile (permanent) carbon only, the carbon dioxide captured is worth $515/ha/yr. Outrageous prices? Only the rate of sequestration is disputed. Others are seeking to verify these findings.

Conventional core sampling rarely goes deeper than 10-15cms because it is believed that most of the activity takes place in the highest profiles. But Dr Jones has employed 110cm samples in her Australian Soil Carbon Accreditation Scheme. In fenceline comparison trials on carbon farmer Col Seis's "Wyona", Dr Jones found more activity in lower profiles in the stable humic fraction. Here is an extract from her report of what she found deep down below.

Carbon that counts

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 form in 10 years when super-phosphate is not applied and plants are managed to maximise their photosynthetic potential. In the last two years studied (2008 - 2010), the LHS soil has sequestered 33 tonnes of CO_2 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 by microbes energized by increased levels of liquid carbon. In this positive feedback loop, sequestration enhances mineralization which in turn enhances humification.

The soil profiles here are from neighbouring paddocks where slope, aspect, parent material are similar.

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 humus was formed against the back-drop of 13 years of below-average rainfall in eastern Australia. It is also 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. The surface increment, 0-10cm, shows high levels of labile carbon, indicative of rapid turnover. This 'active' carbon is important to landscape function and the health of the soil food-web. 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. The Kyoto Protocol, which relates only to carbon sequestered in the 0-30cm increment, completely overlooks the 'sequestration of significance' in the 30-60cm increment. Carbon sequestered below 30cm is important as it indicates good root penetration and high levels of microbial activity and is protected from oxidative decomposition. Deeply sequestered carbon alleviates subsoil constraints, enhances landscape hydrology and iimproves mineral density in plants, animals and people.*

Property owner, Colin Seis can now carry twice the number of stock at a fraction of the cost. Nevertheless, if the land management were to change, the increased levels of humus (non-labile carbon) now present in his soil would remain for hundreds of years. In addition to reducing levels of atmospheric carbon dioxide, 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 of soil. The levels of acid-extractable minerals in the LHS soil profile are higher than those on the RHS soil in the proportions illustrated in Table 1. Levels of plant-available minerals 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 path-way 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. A standard soil test provides very little information about the bulk soil and the minerals potentially available to plants. Most test reports list 'plant-available' nutrients (that is, nutrients not requiring microbial intermediaries for plant access) and if requested, acid-extractable minerals. With respect to phosphorus, for example, the results would be designated as Colwell, Bray or Olsen P for the 'plant-available' levels and Total P for the quantity of P that is acid-extractable. Other techniques, such as x-ray fluorescence (XRF) would be required to determine the composition of the insoluble, acid-resistant mineral fraction, which comprises 97-98% of the soil mass. 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, plus the newly fixed N, enable humification to rapidly proceed. 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 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. Any measurements made outside of institutionalised science are branded 'anecdotal'. When pastures 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.*

The Hidden Costs of Soil C?

The GRDC's Ground Cover article: "The hidden costs of sequestering carbon in the soil" (Passouria et.al., CSIRO) seeks to prove that it would cost too much to grow soil carbon because of the price of nitrogenous fertilisers. "The C content of humus is about 60 per cent, so that every tonne of it contains 600 kg C (equivalent to 2.2 t CO2), and about 60 kg N, 12 kg P, and 9 kg S. Given that these amounts have to be locked up for as long as the carbon is stored, the question arises of what is the value of these required nutri-ents? The simplest assumption is that their value equals the cost of replacing them with fertiliser."

The question has been framed to make the answer appear to be inevitable. The question should be, "Where can these required nutrients come from?" The source determines the prices. Once the frame is set, the next step is inevitable: "The simplest assumption" involves the application of expensive artifical fertilisers. After that shift, soil carbon is doomed.

"Carbon trading is normally based on a tonne of CO2 equivalent, of which there are about 2.2 tonnes per tonne of humus. Thus, if the trading price for CO2 is, say, $20 per tonne, then humus would be worth $44 per tonne. This is but a quarter of the estimated value of nutrients locked up, as shown in the Table."

The lead author kindly sent us an advance copy of the article, with these comments: "I am aware of Colin Seis's remarkable achievements, and I have wondered how he has succeeded in increasing soil organic matter in the topsoil by 2%. If that increase is largely humus, then it is likely to contain, in organically bound form, about 2 tonne/ha of N, 400 kg/ha of P and 300 kg/ha of S. I puzzle about where such large amounts could have come from."

Now he has asked the right question. Col Seis says the answer is: soil microbiology. "They should ask their own people," he says. "It's no mystery. The mystery is that they can completely ignore what goes on in the soil and write these articles." Free-living nitrogen-fixing bacteria and symbiotic fungi can release and make available to plants vast amounts of the N, P, and S locked up in the soil after years of over-application of fertilisers. A CSIRO Fact Sheet says: "We know the current amount of nitrogen fertilizer applied per year is about 100 Megatons of nitrogen. However, we do not have an accurate knowledge of the amount of nitrogen addition through nitrogen fixation, although estimates are between 50 and 200 Megatons of nitrogen per year."[23] A NSW Department of Primary Industries fact sheet says, "Rhizobium bacteria ... can fix 100kg of nitrogen per hectare per

23http://www.csiro.au/resources/GlobalNitrogenFixation.html year."[24]

In 1998, a CSIRO team claimed that Australian agricultural soils may be holding up to $10 billion worth of phosphorus, as a result of fertiliser applications. "The rural industry spends $600 million each year on phosphate-based fertilisers, yet often only about 10 to 20 per cent of the phosphorus is directly used by plants in the year it is applied," said CSIRO Plant Industry researchers Dr Alan Richardson and Dr Peter Hocking[25]. "The remaining phosphorus becomes locked-up in the soil," he said.

If the right bacteria and fungi are present, more nutrient means more growth, which means more microbial activity and more biomass to enrich the soil. "When phosphorus is scarce in soil, plants that have developed mycorrhizas on their root systems have greater access to and take up more phosphorous than others," according to the University of Western Australia's Soil Science Department.[26] The belief that only by introducing organic matter from outside the system can organic carbon grow seems to dominate thinking in high places. But wasn't this idea superseded long ago? "Numerous studies have shown that the introduction of strains of [bacteria] into the rhizospheres of cultivated plants led to significant increases in grain yield as well as total dry matter... The stimulations observed are most likely due to the production of growth hormones by these bacteria."[27]

Soil organic matter (SOM) can supply much of a farmer's Nitrogen needs. "In cropping systems, as much as 50%-80% of the N can be supplied from SOM and nearly 100% of the N in native ecosystems," writes Professor Charlie Rice in his book Soil Carbon Management. This percentage represents 11-300kg N ha-1 for a crop.[28] Nitrogen, like Carbon, is mobile. It cycles. Most N in soils comes from the air and is absorbed by micro-organisms associated with legume plants. N is fixed by legumes and stored in the soil in organic forms, to be broken down by other microbes – via two processes: mineralisation and nitrification, via which it is transformed into ammonium and nitrate.[29]

Former NSW Department of Agriculture agronomist Adam Wilson told The Land that the best way to build up a N bank is to add carbon to soils. Management that builds C also builds organic N because both processes rely upon interactions between rootmass and microbes. He recommends adding organic carbon via composts, green manures or planned grazing, avoiding highly alkaline fertilizers which burn up C and humus, minimum tillage, and a legume or pasture rotation

24http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/41639/Microbes_and_minerals.pdf

25http://www.csiro.au/files/mediaRelease/mr1998/Raiding10BillionPhosphorusBank.htm

26 http://www.soilhealth.segs.uwa.edu.au/components/fungi

27 Davet, Pierrre, Microbial Ecology of the Soil and Plant Growth, 2004

28 Smith, J.L., Papendick, R.I., Bezdicek, D.F., and Lynch, J.M., Soil organic matter dynamics and crop residue management, in Soil Microbial Ecology, Metting, F.B., Jr., Editor, Marcel dekker, Inc., New York, 1993, pp65-94.

29 Charman, P.E.V., Soil Nutrient Decline in Charman, P.E.V. & Murphy, B.W., Soils: Their Properties and Management, Oxford U Press, 2000

Compost 101

The Role of Humus Compost in Carbon Farming

YLAD LIVING SOILS

High quality humus compost is the 'glue' that holds the pieces of a sustainable soil fertility system together. It is produced by microbial and thermophilic (heat) decomposition of plant and animal feedstock followed by microbial polymerisation or build-up of humic substances in long chain polymers of humus, containing beneficial microbial population.

The production is a 10 week aerobic controlled cycle that is consistently repeatable with predictability. This aerobic process creates an optimal environment for aerobic microbes to flourish. High quality humus compost builds a microbial environment in which beneficial microbes thrive and multiply.

All too often organic matter that has been simply broken down is labelled compost. The real value comes after breakdown when long chain polymers of humus are produced by microbes that are supplemented to the compost by inoculation. Organic matter is not humus unless it has been through the body of a microbe.

Daily testing of temperature, carbon dioxide and moisture are maintained throughout the 10 week process with these levels determining when the windrow requires turning.

Moisture guard fabric covers make it possible to develop quality compost even in poor weather cond-itions and reduce leaching in wet weather conditions.

Extensive quality control testing of Humus Compost shows it far exceeds current industry standards. The finished compost is no longer waste or residue. It is a high value, natural, humus-based healthy soil builder.

It's unique maturity and stability lends itself to a myriad of uses and applications across a diverse range of soil based industries. Demand for Humus Compost and Compost Mineral Blends is rapidly growing because of its all-round leading edge performance in creating healthy, balanced, highly fertile soils.

The microbial profile in the soil is influenced by the microbial environment of the compost. We need to ensure that these species are beneficial to plant growth, yield and quality.

Humic substances also exert magnetic forces that expand clay colloids increasing soil porosity.

10 Years on the Frontier of Farm Fertility

In 2012 YLAD Living Soils celebrates a decade since it decided to supply fellow farmers with a sustainable biological fertility and management system, at a time when long-held industry practices did not recognise that soil health contributed to healthy sustainable production and the health of the planet.

This meant going against influential authorities to popularise what was fringe at the time, but what has now become accepted practice. YLAD Living Soils use Humus Technology® and microbial balancing technology to increase the long term productivity, sustainability and profitability of farms through a systemic use of sustainable biological fertilisers and management practices as well as alternate fertility products.

By re-localising fertiliser and food production YLAD Living Soils uses local waste, producing local high quality fertiliser to grow local food as a sustainable option to enhance the local economy.

YLAD produces 5000 tonnes Humus Compost, HumusPro™ to distribute to farmers to rebalance soils, as well as educating other farmers in the production methodology to produce Humus Compost from local waste products.

Fourth generation farmers Bill and Rhonda Daly established YLAD Living Soils in Young NSW in October 2002, with the slogan 'Putting Life Back into the Land'. In 2001, Rhonda had faced and survived a major illness in 2001 that was linked to exposure of toxins present in chemical farming. Rhonda's diagnosis became the catalyst for a search and rescue mission to improve the health of our country's soil, the lifeblood of every farming practice. Mounting scientific evidence and direct experience in farming and the environment convinced the Daly's that chemical farming was having a devastating effect on human health.

It was an idea whose time has come: 130 people attended the first Biological Farming Seminar in October 2002. In 2002 YLAD Living Soils became distributors of biological fertilisers for Nutri-Tech Solutions in Queensland, the largest supplier in Australia,.

Rhonda and Bill had the opportunity to study Humus Compost Technology™ in 2005 in the USA. In 2006, YLAD Living Soils introduced Humus Technology® into Australia from the USA, for the production of high quality humus compost and education in Humus Based Soil Fertility. YLAD Living Soils became the distributors for Midwest Bio-Systems' Aeromaster Composting and Tea Extraction Systems in Australia and New Zealand.

10 YEARS of Greening Agriculture 2002-2012

The company has set up 42 composting operations around Australia and New Zealand, training farmers how to produce Humus Compost and become less dependent on fossil fuel fertilisers and toxic chemicals. They have also set up 20 Compost Tea Extraction Units around Australia that enables the reintroduction of beneficial soil microbes into the soil and -onto the leaf in a liquid form.

Today the manufacturing of YLAD HumusPro™ takes place at the YLAD Living Soils' Composting Site on the Moppity Road.

After nine years of running YLAD Living Soils from an 'on farm' office, growth saw the business move into new premises in Young's CBD at 2 Chillingworks Road. To enable the education of other farmers, YLAD Living Soils have developed their own farm, "Milgadara", into a model biological/humus farm and, using the adage "practice what you preach". The farm provides opportunities for people to see for themselves the benefits of using more sustainable methods, and learn about the practical implementation of biological/humus farming.

'Milgadara' model farm has been featured on national television programs including, Landline and Costa's Garden Odyssey. These programs have offered wide spread coverage giving viewers the opportunity to learn more about the benefits of Humus Technology™ and Biological Farming Systems.

YLAD Living Soils have undertaken independent paddock trials on YLAD HumusPro™ Pellets and YLAD Compost Tea in broadacre cropping, resulting in very encouraging data giving farmers confidence that they can reduce fossil fuel based fertilisers with locally produced fertilisers.

YLAD Living Soils is an Australian owned company formed to supply a large range of biological, organic and humus compost fertility products and programs that support the natural balance of the physical, chemical and biological aspects of the soil, lessening the reliance on conventional chemical fertilser inputs.

Mounting scientific evidence and direct experience in farming conditions has shown that building humus in the soil contributes to the sequestration of soil carbon, confirming that soils have an important role to play in reducing green house gas emissions and the health of our environment.

Brewing Compost Tea

Tea Extraction is a process of liquefying Humus Compost. The basic principle of the extraction system is to extract soluble minerals, humus and microbiology from humus compost.

The Aeromaster Compost Tea Extraction System is a high production compost tea unit that can make 50,000 litres per day of extracted tea which remains viable for up to two weeks or until activated with ActPak. The Extractor consists of a round tank that has a large round screen in it and the opening at the top of the tank exposes the inside of the large round screen. It has an air compressor pump, discharge water pump and a dump valve. There is an air compartment attached to the bottom of the tank that blows air up through small holes in the bottom of the tank. This is why air is always first turned on and lastly turned off in order to keep the water and sludge residue from entering the air compartment. The outlet for draining out the extracted tea is strategically mounted approximately 45 cm from the bottom of the tank. The reason for this is to capture the un-dissolved compost residue in the tank. 37.5 kg of compost will produce 1000 litres of extracted

Nutri-Life Platform™ Extends your Roots

The Mechanics of Nutri-Life Platform™

A key component of biology is the profound plant/mycorrhizal fungi relationship. Mycorrhiza forms a network of filaments that associate with plant roots and draw nutrients and water from the soil that the root system would not be able to access otherwise.

Platform™ contains four species of **Arbuscular Mycorrhizal Fungi (AMF)** and at least 1500 to 2000 infective hyphae per gram of **Trichoderma**. *The number of spores per gram is impressive. The world standards is 40 spores per gram but Platform contains at least 500 spores per gram.*

Benefits

- Mobilises phosphorus & nitrogen and other important soil nutrients
- Defends root system reducing phytophthora, fusarium, phythium & rhizoctonia
- Boosts phosphate and zinc availability
- Can reduce fertiliser requirements through improved nutrient uptake
- The ability to suppress weeds
- Builds Humus

Platform™ *tolerates a wide range of commonly used seed dressings and crop protection products*

Standard application rate:

Seed Treatment*
50 grams per hectare mixed in sufficient water (or Seed-Start™) for good coverage (approximately 5 L/tonne of seed).
*Ideally include Seed-Start™ at 5 L/tonne of seed to provide broad-spectrum nutrition and biological germination support.

Fertigation/Soil Application
Small crops, viticulture, orchards and sugarcane: 200g/ha

Golf Courses: 50 g/ha
Pasture: Existing 40 g/ha. New Plantings 60 g/ha

Seedlings/Runner/Tubestock Planting Treatment
Dip seedlings/runner/tubestock in a solution containing 50 grams of Platform™ per 100 L of water.

REAL RESULTS FAST!

Just 18 days after sowing [illegible] wheat has absolutely jumped out of the ground- thanks to Seed-Start™ (@5L/tonne of seed) and Nutri-Life Platform™ (@ 50g/ha)

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YLAD Living Soils
Putting life back into the land

Benefits of Compost Mineral Blends

Compost mineral blends are custom designed for each situation. By blending minerals with humus (or long chain polymers) each mineral particle is coated like an insulator, keeping minerals from fighting with each other and from tying themselves up and creating imbalance. Mixing the fertiliser with humified compost allows those minerals to chemically react with the humic acids in the compost. The resulting humic salts are very plant available yet bound to the humus, minimising leaching and evaporation.

Mixing soil applied nutrients with Humus Compost ensures they are available for soil, microbe and plant use whenever there is moisture in the soil. It also buffers any adverse effects individual nutrients may have in the soil in their raw form. The fertiliser is utilised more efficiently thus less is required to grow the same crop. Humus has a much stronger magnetic attraction to itself for every mineral known to man, even more than minerals themselves.

Three issues we have to address with conventional farming are: 1. Nutrient tie-up 2. Nutrient leaching 3. Nutrient evaporation

If minerals are not coated with humus when the mineral touches the root it becomes bare creating an unbalanced and unhealthy plant with low nutritional value.

Example Program of Compost Mineral Blend

The minerals that are added into a Compost Mineral Blend are determined by soil test results. The first things considered from the soil test results are: CEC, Base Saturation levels and Organic Matter and. Secondly, the major and minor traces are examined to determine if any extra minerals need to be added to the blend.

An example blend for soil remediation would contain: 500kg/1 tonne ha Humus Compost, 150kg/ha Gypsum, 500kg/ha Lime, and 80kg/ha Soft Rock Phosphate.

In this example the soil test would have shown a high level of hydrogen, low calcium, low phosphorous & high potassium. The compost rate can be mixed at as low as 300kg/ha, the minimum rate to gain any measurable benefit and increase water holding capacity.

The humic acid portion of the compost will expand the clay colloid in the soil creating a porous structure, allowing more oxygen and water to penetrate, alleviating the problems of the compacted soils.

Lime is added to the compost to balance the cations, the nutrients supplied in this system are plant available and less likely to leach.

Mineral nutrients blended with humified compost are bonded to and buffered by the available humic compounds and acids facilitating absorption by plant roots.

The gypsum is added to fizz the clay colloid allowing for the correct balance of cations to settle back, alleviating the high levels of potassium. Gypsum is also a good source of sulphur.

The humus compost contains a large population of beneficial microbes and has been inoculated with supplemental microbial species to enhance its soil fertility value. These microbes also deliver enzymes, root stimulants, and the humic compounds.

YLAD Living Soils
Putting life back into the land

Triggering terra biologica

Soil biology 'trigger' technology was introduced to Australia in 2006 by Best Environmental Technologies. Its product TM Agricultural Soil Activator was first trialled by 9 farmers in the northern wheat belt

of WA. Thousands now use this "trigger" technology to activate the native biology in all soil types. The first thing that happens in the triggering process is that the biology loosens the soil to allow oxygen in. This formation of soil structure is achieved by bacteria gluing small soil particles together to form larger particles called aggregates. Soil with larger aggregates has the ability to hold oxygen, water and let roots penetrate the soil easier and deeper. As a comparison if you picture compacted soil like a jar full of flour and healthy soil as a jar full of marbles you can see that the marbles have very large areas to hold water and oxygen and let the roots grow through. This good soil structure helps in both dry areas and wet areas. In dry areas when we do get rain we can now allow that water to soak into the soil and be stored in the sub soil, instead of running off the paddocks or only wetting up the top few centimeters. In wet areas water is now able to flow into the soil profile and not just sit on the surface causing water logging. As the soil structure improves over time and the biology starts to break down plant residues in the soil forming organic matter and carbon even more water holding capacity can be achieved. Your soil tests will also start to change with increased residual nutrients through increased fertilser efficiency and unlocking tied up nutrients, shifting PH levels towards neutral, balancing of nutrients including reductions in sodium and aluminium. As organic matter and soil carbon levels rise, so do CEC levels. The benefits and changes to your soil are easily measured with standard soil tests and will transfer to leaf tissue analysis in crop. Bacteria start to colonize around the roots gluing soil particles to the roots called rhizospheres. These colonies cover the roots and 'hide' the plant from the paddock. The roots are no longer exposed to the harsh conditions of the soil but are now buffered by the biology. The inside of the colonies are PH neutral and have extra water brought to them by fungi that penetrate deep into the sub soil to access water and nutrients. The nutrients - many of which are not plant available - are refined by the bacteria and made plant available. Bacteria also refine the synthetic fertilizers, greatly increasing the efficiency and reducing losses due to gassing off, leaching, and lock-up

with other elements in the soil. With the increased oxygen in the rooting zone the plant will put energy into producing the fine fibrous roots. It is these roots with massive surface area that do the majority of uptake. You will notice that in tight, compacted soils plants do not have many of these fine roots as oxygen is the limiting factor. This ball of fibrous root mass also acts to protect the root system from predators such as root feeding nematodes, which cannot move through the fibers,, getting immobilized and becoming food for the biology.

Conventional farm systems using synthetic water-soluble, salt-based nitrogen (N) fertiliser force the plants onto a nitrogen fat cycle. The plant pulls up large amounts of synthetic N with the water, forcing the plant to grow too fast and resulting in an unbalanced unhealthy state. The water evaporates out of the plant and leaves the salt behind. This dehydrates the plant, forcing it to pull more water which contains more salt, and so the cycle goes. The cells of the plant under this cycle are full of water and N, they have a balloon shape to them and actually leak water and N where the cells have gaps. This allows any air borne spores such as powdery mildew or rusts the opportunity to land on these leaks, gain energy from the N and have a direct path into the plant for a food source. It is also a very inefficient way to use water. Poor cell structure also hinders the plants ability to move nutrients within itself (translocation). This further imbalances the plant causing stress and mineral deficiencies.

Plants in a healthy soil are not on this cycle. The bacteria tie up the N and allow the plant to take up water. When the plant needs N, it will raise its sugar (brix) levels through photosynthesis and trade this carbon and other exudates into the rhizospheres. The plant feeds the bacteria and the bacteria feed the plant.

Plants that are growing in healthy soils have cells that are rectangle in shape and fit together like building blocks. They have a leathery smooth texture with no leaks. This is a first line defense against disease. The cells are full of water and sugars instead of water and N. This increases frost protection. Insects that feed on the sap of the plant - like red legged earth mites, locusts, etc. - cannot digest the highly complex sugars and proteins of a healthy balanced plant, thus giving a natural deterrent against these types of pests.

All the benefits of healthy soil transfer to plants, and thus transfer to the animals that eat those plants. TM Agricultural treated paddocks produce plants that are higher in mineral content and carbohydrates. This is key for animal health and production. Animals do not eat to get full. They eat for minerals. Animals grazing on high mineral plants eat less dry matter, spend less time and energy grazing and gain more weight. Many advantages have been observed in the health of animals, a more content animal with reductions in runs, snots, scours, lice, birthing problems, milk fever etc. In essence the animal becomes balanced in minerals as does the soil.

There are many benefits that have been observed through extensive case studies and trial work including: Breakdown of stubble residue, Increased soil structure, allowing for increased water infiltration and retention, improved nutrient efficiency, improved carbon/organic matter build up, root development has been observed to increase substantially. Also observed has been a reduction/elimination of hard pan areas in paddocks, reduction of cracking in clay soils and a reduction in chemical use.

Darren Sander and Darryl Paulhus anchor Best Environmental Technologies's fast-growing operation in Australia.


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Soil Health at Kentish Downs

Rob Martin, Kentish Downs Poll Dorset Stud, Holbrook NSW

I first started researching biological farming in 2005 and quickly found the biological farming service industry to be full of snake oil salesmen and witch doctors, all with a very expensive solution to the problems they perceived I had. In 2006 my wife and I attended a soils course run by the NSW DPI which raised more questions than it answered. We discovered that we had very high P levels and that our Ca/Mg ratio was within target but we had high aluminium and low ph, a fairly common story we were to find out. At that point I was determined to change what we were doing and put a stop to the acidification that was going on in the soil and make use of all the stored P. We had been liming the farm at differing rates up to 2.5t/ha and weren't seeing much movement in our ph although the ca levels in the soil were significant enough to edge the ph upward. By the end of 2006 we decided to cease the use of acid based fertilizers and the crops in 2007 were planted with no fertilizer at all and the pastures and lucerne also received nothing. As we were still under the affect of a major drought the consequences of no fertilizer didn't really show up as what crop we did have was baled for hay. In early 2008 we had some summer rain and by early march we were spraying melons, which I got a contractor in to help with. In the back of his Ute was a yellow drum with some reference to biological farming on the label. I rang the 1800 number and was put in touch with my local distributor who as it turned out was a local farmer, and after some

investigation from other farmers who had been using it we decided we had nothing to lose and to give it a try. We very quickly realised the benefits of TM Agricultural and in that first year applied to the whole farm. During the winter of 2008 we could see no difference above the ground but the root development of not only cereals but also perennials were 2-3 times more than we would normally expect. At the end of 2008 I noticed our crops and pasture paddocks staying green while our neighbours started dying back, we also noticed that our sheep did not need crutching prior to shearing as they normally do and our agronomist commented that we had significantly less capeweed. Since 2008 we have continued with the program and found not only are our sheep less daggy, they are also less susceptible to worms. We have also experienced a gradual increase in the flock fertility, but most notable was 2010, our wettest year on record with 1225ml of rain , we had very little foot problems in any of our sheep which indicates the sheep are grazing some very healthy pastures.

"Australia leads the world in carbon farming," says world authority

Australia leads the world in carbon farming, according to Professor Rattan Lal, America's most respected soil carbon expert. "I think that Australia's Government and farmers are way ahead more so than the United States... The awareness of policy makers and the tremendous interest from the farming community with the Carbon Coalition group here which is incentivising its colleagues and members community into that. I think Australia is going to set an example to the world community on this type of carbon trading and farming carbon, where farmers can buy and sell carbon, and trade it, and make carbon in soil another income stream for them through carbon credit trading." Lal was in Australia for the Soil Carbon Summit staged by the US Studies Centre in 2011.

Biological for Beginners

Practicing biological principles can deliver greater yield and more carbon while reducing the need for chemical intervention, says Graeme Sait.

1) Mineral management – Soil testing is the first step forward, but choose a lab that understands mineral balancing. All soils have an inherent capacity to store the major cations (calcium, magnesium, potassium and sodium) and this varies according to the clay component of the soil. An oversupply of these cations (due to a misunderstanding about the importance of balance) can be as destructive as an under supply. Your chosen lab must understand the importance of the key mineral ratios, beginning with the all-important calcium to magnesium ratio (varies from 3:1 up to 7:1 depending on soil type). Other key soil balancing ratios include the phosphorous to zinc ratio (10:1), the potassium to sodium ratio (at least 4:1), the magnesium to potassium ratio (1:1 in terms of ppm) and the relationship between iron and manganese (slightly more iron than manganese is required).

2) Building biodiversity –A healthy soil should contain over a billion organisms in a teaspoon, involving tens of thousands of different species. The path back to productive biodiversity involves compost, compost tea, inoculums of mychorrhizal fungi and biostimulants. Mychorrhizal fungi are responsible for over 30% of the humus in your soil and you can now introduce them for as little as $5 per hectare. Repopulating other beneficials can be an inexpensive practice if you brew them up yourself. After multiplying out your new workforce you need to send them off to work with a lunch box to encourage colonization. Liquid fish, kelp and humates are favourites for beneficial soil organisms.

3) Kick starting the seed – a well formulated nutrient package surrounding the germinating seed can improve germination and provide a mothers milk-like, kick start to the young plant, which invariably translates to yield gains. Seed treatment can cost as little as $2 per hectare.

4) Magnifying and stabilising fertilisers – soluble humate granules are the best way to enhance the efficiency of fertiliser inputs. Research has confirmed increases in plant nutrient uptake of at least 30%, when fertilisers are combined with small amounts of soluble humates. The release of natural phosphate fertilisers is enhanced and the humates also chelate minerals to enhance their effect.

5) Precision nutrition –Feed the plant what it needs, when it needs it and you will reap the rewards. Leaf testing provides a valuable insight into these requirements. NTS Plant Therapy is an excellent tissue testing and analysis and advice service.

6) Increasing cell strength – the biological approach is proactive in that we strive to create conditions that minimise pest pressure. An important strategy involves building the strength of the cell wall to create an impenetrable barrier. The tools for this task are calcium and silica. The trace mineral boron improves the uptake of both of these minerals. Silica also serves to increase stress resistance, stem strength and photosynthetic response.

7) Root Zone revival – If you can't afford to correct your entire soil, then address the action zone.. Root zone aeration can be improved by liquid injecting micronized gypsum and micronized humates at planting. An investment of $5 per hectare could also allow the inclusion of an inoculum of mycorrhizal fungi. These creatures can improve aeration around the roots to while boosting the uptake of phosphorous and zinc, protecting from disease, improving nitrogen fixation and enhancing potassium availability.

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4) NTS Agronomists will **know your crop**. They work with over 130 different crops in over 40 countries.

5) NTS have developed **solutions** for most problems. They have a massive range of innovative products (over 200) to address multiple issues in multiple crops.

6) NTS believe that **knowledge** is empowerment and they have developed ground-breaking training programs, including the internationally acclaimed, four day, Certificate in Sustainable Agriculture.

7) NTS are also World leaders in **organic agriculture** having developed the largest number of certified products of any company anywhere. The NTS certified organic range now encompasses 64 problem-solving inputs.

8) NTS products feature many **unique inputs**, including Platform™, an inoculum involving huge numbers of mycorrhizal fungi and trichoderma that can generate a great response for as little as $5 per hectare (mycorrhizal fungi account for 30% of the planet's stable humus).

9) NTS are renowned for their selfless focus upon **your needs** rather than their profit. You will always be advised according to what is best for you and that may not involve their inputs.

10) NTS offer cutting edge, **consulting services** including Soil Therapy™ and Plant Therapy™. These services involve advanced soil and plant test analysis with nutrition programming, tailored to your budget.

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Is fertilizer bad for carbon?

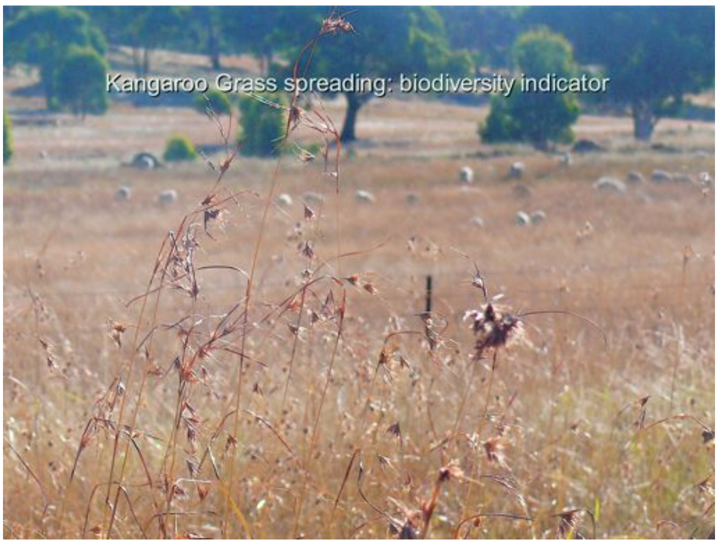
"In theory, any management practice that can increase production from an area of land should lead to increased SOC storage because of the increase in carbon inputs." Dr YN Chan included fertilizers in his list of practices.

But CSIRO researchers reported that conventional fertilizers contribute to the loss of drought-resistant native perennial grasses which are critical in the sequestering of carbon in pasture soil.

Senior Principal Research Scientist with the CSIRO Dr Sue McIntyre says fertilizers do more harm to biodiversity and native species than grazing animals: "While it is true that over-grazing can have serious impacts on the soil and reduce habitat quality for plants, birds and animals, the effects of fertilizer use are far more permanent," she says. "Because many native plants and animals are adapted to drought and low fertility soils, they fail miserably to persist when superphosphate and exotic legumes are added." Most native species can be wiped out entirely in one commercial spreading of fertilizer, she says. In the drought fertilized pasture had been unable to cope with heavy grazing, due to the loss of perennials. "The perennial cover is critical because although you can over –graze any pasture, with annual pastures you're always going to get a period of the season when there's bare ground with a vulnerability to erosion. Where native and perennial species dominate, you're getting more persistant, more resistant plant cover on the landscape."

Fertiliser inputs means grazing pressure has to be increased to get higher returns to cover the input costs. "Pastures tend to lapse towards annual dominance under these conditions and erosion risks increase." Eucalypts cease regenerating because their seedlings are grazed and out-competed by fast-growing exotic pasture. The result is a decline in habitat for wildlife.

Some native perennial grasses are fertilizer tolerant, such as Mircrolaena and Wallaby Grasses.



The Myth of N for Soil C Sequestration

Intensive use of N fertilizers is motivated by the economic value of high grain yields and is generally perceived to sequester soil organic C by increasing the input of crop residues. This perception is at odds with a century of soil organic C data reported for the Morrow Plots, the world's oldest experimental site under continuous corn (Zea mays L.). After 40 to 50 yr of synthetic fertilization that exceeded grain N removal by 60 to 190%, a net decline occurred in soil C despite increasingly massive residue C incorporation, the decline being more extensive for a corn–soybean (Glycine max L. Merr.) or corn–oats (Avena sativa L.)–hay rotation than for continuous corn and of greater intensity for the profile (0–46 cm) than the surface soil. These findings implicate fertilizer N in promoting the decomposition of crop residues and soil organic matter and are consistent with data from numerous cropping experiments involving synthetic N fertilization in the USA Corn Belt and elsewhere, although not with the interpretation usually provided. There are important implications for soil C sequestration because the yield-based input of fertilizer N has commonly exceeded grain N removal for corn production on fertile soils since the 1960s. To mitigate the ongoing consequences of soil deterioration, atmospheric CO_2 enrichment, and NO_3 pollution of ground and surface waters, N fertilization should be managed by site-specific assessment of soil N availability. Current fertilizer N management practices, if combined with corn stover removal for bioenergy production, exacerbate soil C loss.

A half century of synthetic N fertilization has played a crucial role in expanding worldwide grain production, but there has been a hidden cost to the soil resource: a net loss of native SOC and the residue C inputs. This cost has been exacerbated by the widespread use of yield-based systems for fertilizer N management, which are advocated for the sake of short-term economic gain rather than long-term sustainability. Fertilization beyond crop N requirements could be reduced substantially by a shift from yield- to soil-based N management, ideally implemented on a site-specific basis. This strategy may be of value for reversing the ongoing organic matter decline of arable soils, but several decades will likely be necessary before any such benefit can realistically be expected to emerge. In the meantime, caution is warranted in avoiding excessive N fertilization, and especially with the current trend toward the use of crop residues for bioenergy production.

S. A. Khan,* R. L. Mulvaney, T. R. Ellsworth, and C. W. Boast University of Illinois, J. Environ. Qual. 36:1821–1832 (2007)

Fatal Mistake: Slashing N too soon

By Graeme Sait

It is common to encounter growers, enthused by the potential of the biological approach, who decide to reduce their nitrogen inputs. This can be a trap in some soils and yield reductions can dampen the ardour of the most passionate convert. This problem is most pronounced in high magnesium soils and this can be avoided if you understand the mechanics of nitrogen utilisation in the soil.

Outgassing your investment

There are three reasons why it may not be a good idea to reduce nitrogen inputs in high magnesium soils. The first is the alkalising effect of high magnesium. This mineral has 1.4 times more impact upon soil pH in comparison to calcium and high pH sponsors the instability of nitrogen. There is increased outgassing of ammonia in these soils, so more nitrogen is required to achieve the desired response.

Nurturing the N fixers

The second and third reasons are linked to the role of microbiology in the whole nitrogen equation. Many growers assume that most of their nitrogen requirements are addressed with applied N. The majority of the nitrogen needed for high production systems comes from natural sources. Electrical storms oxidise nitrogen gas in the atmosphere and the nitrate nitrogen that results charges raindrops with a bounty that greens all that it touches. Nitrogen-fixing bacteria in the soil and on the leaf creatively combine molybdenum and iron to manufacture nitrogenase, an enzyme that mines the massive reserve of atmospheric nitrogen (74%) to fuel plant growth. If we understand these processes, we are more likely to create conditions conducive to their success. Free-living nitrogen-fixing organisms, for example, are highly aerobic. In fact, Azotobacter are the most aerobic creatures on the planet. Tight, closed, high magnesium soils are those that struggle to breathe and their lack of oxygen spells a lack of free nitrogen delivered from the atmosphere.

High magnesium nukes N recycling

Similarly, the potential for nitrogen recycling reduces in high magnesium soils and this signals a greater need for applied nitrogen. Plant protein contains 16% N and this is a recyclable reserve that is there for the taking (assuming you have the aerobic biology present to do the job). The 2.5 tonnes of bacteria per hectare found in a good soil are also a bountiful supply of harvestable N. Bacteria store 17% nitrogen in their bodies and this can equate to over a tonne of urea per hectare if it can be successfully released. This release process is the role of other creatures in the soil including beneficial nematodes. These blind, microscopic worms have a carbon to nitrogen ratio of 100:1. In the process of consuming 20 bacteria with C/N ratios if 5:1 (20 x 5 = 100) to satisfy their carbon requirements, they spew out the 19 units of nitrogen not required. In high magnesium soils, the lack of oxygen means less nitrogen fixation, less recycling and more nitrogen from a bag. If you can improve your calcium to magnesium ratio in these soils you will sponsor more oxygen delivery and reduce reliance upon applied nitrogen that is destined to increase in price in line with rising oil prices (peak oil).

Visit www.nutri-tech.com.au to access a host of Graeme Sait's problem-solving articles

The Role of Trees in Carbon Farming

In the imagination of many dedicated to the restoration of Australia's environment the continent was once heavily forested from coast to coast. The grasslands and pastures and cropping areas were all cleared by early colonists who then proceeded to degrade the landscape by over use. The logical solution is to return as much of the rural landscape to forest by locking up grazing land and encouraging native wildlife to repopulate the area.

This concept was behind the purchase and locking up of Henbury Station, near Alice Springs, a 5000sq km former cattle enterprise was bought by RM Williams Agricultural Holdings, which resulted in the removal of 17,000 cattle. But the assumption is wrong, according to some researchers. Botanical historian Eric Rolls has studied the reports of explorers and official tree counts and concluded Australia was not dense forest when the First Fleet arrived: "To a large extent, the Australia of 1788 was characterised not by forests but by open woodlands and grasslands. Yet many of these areas now contain dense forest. Possible explanations for this dramatic vegetational shift include the cessation of Aboriginal burning regimes and the displacement by domestic stock of mammals that ate tree seedlings."[30]

Dean Graetz and his fellow authors of Looking Back , published by the CSIRO Office of Space Science & Applications, state that the landcover of 1788 was '. . . characterised not by forests but by woodlands; in particular, by the low and open woodlands and shrublands where the overstorey is so sparse it covers less than 10% of the ground surface.' This area covered 60 per cent of the continent. Tall closed forest, tall open forest and closed forest covered 1.3 per cent only. The rest was heath and other shrubs of varying density. [31]

On the other hand, there was significant over-clearing which needs to be restored, says Rolls: "While Australia's grasslands were being overrun, elsewhere destructive and wasteful felling of timber continued apace. The problems resulting from such clearance began to be widely articulated in the last two decades of the nineteenth century, but general attitudes to ringbarking and felling have changed only slowly. The result of all this is that Australia's vegetation is now thoroughly disorganised. The grassy woodlands have gone and with them birds, animals and numerous varieties of grass. Any attempt to provide an environment suitable for the majority of native plants and animals in temperate Australia must depend on the restoration of a pre-European-type mosaic of interconnected grassy woodlands...

"The social history of a stretch of land demonstrates its environmental capacity. The social history of Australia began about 120,000 years ago. Everything one reads of country two hundred years ago in any area reveals a wondrous mosaic: grassland lightly wooded or bare of trees fringed with forest and dotted with individual shrubs or broken by mixed belts, 'a wildflower garden'. Australia's vegetation is now thoroughly disorganised. Too many

[30] Rolls, E.C., "Land of Grass: the Loss of Australia's Grasslands", Australian Geographical Studies November 1999 37(3):197–213. Eric Rolls is an author and environmentalist. His postal address is P.O. Box 2038, North Haven, New South Wales 2443, Australia.

[31] Graetz, D.R., Fisher, R.P. and Wilson, M.A., 1992: Looking Back: The Changing Face of the Australian Continent, 1972–1992. CSIRO Office of Space Science & Applications, Canberra.

trees grow on what was open grassland, exotic grasses and clovers grow on recharge areas once guarded by dense scrub. Our farming has been so exploitative that salt and erosion threaten our existence. A first, elementary but vital step in improving our methods is to reestablish at least 20 per cent of connected grassy woodlands on all agricultural lands...

"Efforts to correct the awful destruction that has occurred since that time are being confused by attempts to add more trees to Australia in 1788 than were ever there. In particular, Benson and Redpath (1997)[32] have argued that there is no evidence that grassland and open woodland covered most of the landscape at that time, and that most grasslands are the product of large scale land clearance since the time of European settlement. The deficiencies of this work are exposed below. The tree counts cannot be argued with. I quote from the men who made them."

Economic Value of Conserving Native Vegetation

One of the many benefits of trees on crops to be a 22-46% increase in wheat and crop yields in sheltered zones. One of the benefits of trees on pasture growth include a 20-30% higher yield obtained from protected than in unprotected areas of a farm, with annual benefits of $38 to $66 per hectare.33 Native vegetation has a number of benefits for stock production including the actual grazing benefits that stock derive from spending time in remnants as well as increased production arising from enhanced livestock health and pasture production. Over a 5-year trial, a 31% wool production increase and 6 kg (21%) more liveweight was found in sheltered areas compared with sheep without shelter.

Based on a study area near Gunnedah in northern New South Wales a model was developed that indicates that the value of pasture output per farm may be increased by having a certain proportion of pasture area under dry sclerophyll or woodland vegetation. Gross value of pasture output was at its highest level when the proportion of tree area across the farm was at 34%, with no further increases in output being achieved beyond this point. 34

Narromine landholder Bruce Maynard planted 32 hectares of Old Man Saltbush in 1990 as windbreaks between pastures and crops. In six years, the combination of alley farming, an advanced sowing technique and cell grazing has helped triple the farm's stocking rate. Yass Valley grazier John Ive – Carbon Cocky of the Year 2011 – reports that he was able to revegetate 20% of his property without reducing production.

Gillespie (2000) has summarised a range of benefits of Remnant Native Vegetation including:

benefits for adjoining crops;
benefits for adjoining pasture;
benefits for livestock production;
timber for firewood, fencing and brushwood;
forestry;

[32] Benson, J.S. and Redpath, P.A., 1997: The nature of pre-European native vegetation in south-eastern Australia: a critique of Ryan, D.G., Ryan, J.R. and Starr, B.J. (1995) The Australian Landscape – Observations of Explorers and Early Settlers. Cunninghamia 5, 285–328.

[33] Gillespie, R. (2000) Economic Values of Native Vegetation, Background Paper Number 4, Native Vegetation Advisory Council, Sydney.

[34] Walpole, S.C. (1999), Assessment of the economic and ecological impacts of remnant vegetation on pasture productivity, *Pacific Conservation Biology*, 5: 28-35.

carbon sequestration;
increased agriculture production owing to land degradation control – onsite;
increased agriculture production owing to land degradation control – offsite;
honey and beeswax production;
seed collection;
aesthetics for property, adjoining properties and the region;
habitat for animals that help control pests;
tourism and recreation;
research, education and monitoring;
food;
medicinal and perfume resources;
wildflowers and native plants; and
other minor uses.

A number of these values are directly measurable, but others are more difficult to quantify.

The First Forest Offsets Deal

Under a trading deal to reduce deforestation in Queensland, Rio Tinto Aluminium, former Comalco, did a deal in 2006 to save more than13,000ha of native vegetation from destruction to offset one million tonnes of its carbon dioxide emissions. The Agreement was brokered by The Carbon Pool. The deal was overseen and verified by the Federal Government's Greenhouse Office, the predecessor of the Department of Climate Change & Energy Efficiency. The Carbon Pool was based in Lismore, NSW, but three of its five directors were Canberra-based former members of the Greenhouse Office. Rio Tinto Aluminium said the project provided financial incentives to the landholders to forgo their clearing permits and protect the uncleared vegetation for 120 years. The reduction in clearing would generate verified abatement in greenhouse emissions. Rio Tinto Aluminium' said the project was a world first in delivering fully verified greenhouse gas abatement through avoided deforestation. Under the contract the landowner was bound not to clear the land for 120 years. The project included buffer whereby 20 per cent of all abatements were set aside to provide for any potential losses due to things like fire, pests or drought.

Farm Forest Offsets Now Open

One of the first opportunities for farmers arising from the Carbon Farming Initiative is not surprising: native vegetation. It is a "Methodology for Quantifying Carbon Sequestration by Permanent Environmental Plantings of Native Species using the CFI Reforestation Modelling Tool"

This methodology applies to the establishment of permanent environmental plantings. These are plantings that consist of Australian species that are native to the local area of the plantings and may be a mix of tree and understory species or single species if monocultures occur naturally in the area. These plantings have, or have the potential to attain a crown cover of at least 20% and a height of at least 2 metres in the place where they have been established.

Crown cover as a proportion can be estimated by multiplying planting density (trees per hectare) by crown area (in hectares). For example, a minimum density to achieve 20% crown cover with evenly-spread trees for a species with a crown diameter of 3.5 to 4 metres is about 150 - 200 trees per hectare. Table 1 below provides guidance on the ratio of trees to crown cover for a given crown diameter. Planting in clumps or widely spaced rows will increase the required density. Proponents are encouraged to plant more than the minimum number of trees to achieve greater than 20% canopy cover, to allow a buffer for losses.

This methodology can be applied Australia-wide. The vegetation must be established through direct seeding or planting, not regrowth. There can be no harvesting except for firewood for personal use, removing a maximum of 10% of debris per year. Some thinning for the purposes of promoting forest health allowed provided that the biomass remains onsite. No grazing by livestock in the first 3 years after planting to allow the trees to establish. Any grazing after this time must not prevent tree regeneration. The land must have been clear or partially clear of forest for the five years prior to planting. To protect the soil, there can be no ripping and mounding which affects greater than 10% of the area for site preparation on pastures in areas receiving greater than 800mm average annual rainfall. The project must not involve removing invasive native scrub species or woody biomass unless they are weed species and removal is mandated by law.

Table 1: Minimum number of trees per hectare to achieve 20% crown cover[1]

Mature crown diameter (m)	Minimum number of trees per hectare required for 20% crown cover
5.0	102
4.5	126
4.0	159
3.5	208
3.0	283

Environmental plantings establish permanent mixed native species forests in order to sequester carbon dioxide from the atmosphere and store it in the forest biomass. Other benefits can include increased biodiversity, reduced dryland salinity, reduced erosion and shade and shelter for livestock. This methodology uses the Australian Government's Reforestation Modelling Tool (RMT) to model carbon emissions and removals from reforestation projects. The DCCEE has also developed two optional tools to assist proponents define Project Areas (the CFI Mapping Tool) and record carbon abatement (the Reforestation Abatement Calculator). The tools and associated user guides are available from http://ncat.climatechange.gov.au/cfirefor/.

Are Forests The Answer?

Trees have an important role to play in Climate Change Mitigation and Landscape Reclamation. Most farms need more trees. There is not enough shelter for animals nor enough vegetation for native wildlife to travel to their breeding and feeding grounds in most Australian properties. But saying "Yes" automatically to trees is not good carbon policy. Most 'forests' sold as carbon sinks to date were plantations or tree farms that are less effective than natural forests. Tree farms start their life emitting tonnes of carbon because they tear up the vegetation that covers the soil, releasing CO_2 into the atmosphere. Then herbicides are used to kill off other plant species that the birds and wildlife rely on. Despite their attempts to add species mix, the result of the promoters of these schemes is a biodiversity desert. Not an Australian forest.

Pastures equivalent to forest in Soil C performance: A survey by Australia's leading soil carbon scientist Dr YN Chan, comparing pastures and forest soil carbon, found: "There was no significant difference in soil organic carbon stock to 20 cm between paired sites of perennial pastures and native forest."[35]

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[35] McCOY D., CHAN KY., SOIL CARBON SEQUESTRATION POTENTIAL UNDER PERENNIAL PASTURES IN THE MID NORTH COAST OF NEW SOUTH WALES, Austalian Soil Science Society Inc. Proceedings 2008,

Forested soil holds less C than pasture
AUSTRALIAN GREENHOUSE OFFICE: "When agricultural land is reforested there may be significant losses from the soil carbon pool… Soil carbon is likely to decrease initially, as a result of a decline in pasture litter inputs in the early phase of plantation establishment, and then increase as litter input from the forest is added to the system. The decline in soil carbon is usually temporary: as the plantation grows, soil carbon will be replenished from litter fall and root turnover, usually restoring soil carbon stock to original levels within 30 years (Paul *et al.,* 2002).

"If the site being reforested has a high concentration of readily decomposable soil carbon, such as may occur under a heavily fertilised, irrigated pasture, then the soil carbon stock may not reach the level under the previous pasture system. There is some evidence that soil carbon stock is lower under pine plantations than eucalypts (Guo and Gifford, 2002; Paul *et al.,* 2002).

"Significant losses of soil carbon after reforestation are most likely in soils that are high in labile carbon, such as where new plantations are established into pastures that have been heavily fertilised, and enhanced productivity has elevated the soil carbon above native levels. … It would be prudent, in predicting forest carbon sequestration, to assume a decline in soil carbon stock for reforestation of pasture soils"[36]

Pine forests leak soil C : CSIRO: "A decline in soil C has been observed in NSW for pastures planted to radiata pine. There are several other examples in the literature of soil C-content being lower under trees than under matched pasture sites and indeed a process-modelling study of pastures in south-central USA planted to pine plantation predicted a decline in soil organic C down to 1m depth over 50 years."[37]

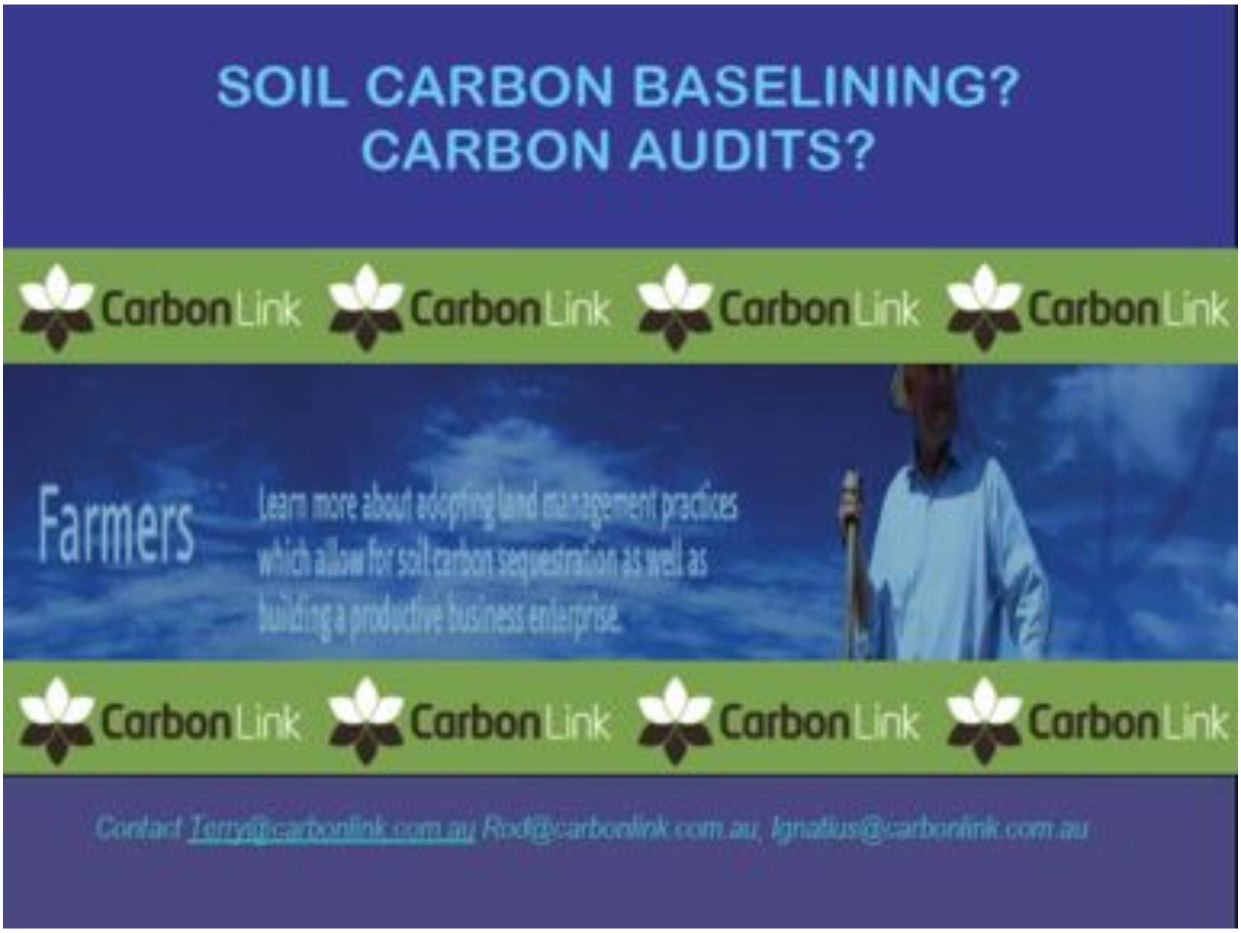
Trees not an efficient sink: Trees can take many years to become a net sink and in the mean time are net emitters:
GREENFLEET: 'There is no immediate fix for an individual's carbon emissions. "People think it's going to be an instant result but it's not," says Greenfleet forester Mick Spiller. "There's no way we can measure the carbon sequestered until the trees are mature. That is counting chickens before they hatch." The reality is that the 4.3 tonnes a driver emits each year will not be sequestered in a tree for many years, perhaps decades.' (Sydney Morning Herald, 16 January 2006)

Forest Ecology & Management: "After establishment, there are reduced inputs of carbon into the soil from prior vegetation or rapidly growing weeds, together with accelerated decomposition of soil organic matter as a result of disturbance, and this leads to a net loss of soil organic carbon. In some systems this loss of soil organic carbon is not balanced by carbon biomass sequestration until 5–10 years after establishment and on some sites, a

www.asssi.asn.au/downloads/soils2008/Tu42%20107-G-McCoy%20et%20al.pdf

[36] Tony Beck, Annette Cowie, Beverley Henry, Miko Kirschbaum, John Raison, "Forestry Carbon Sequestration Review", Cooperative Research Centre for Greenhouse Accounting, September 2005

[37] *Gifford RM, Cheney NP, Noble JC, Russell JS, Wellington AB and ZamitC (1992) Australian land use, primary production of vegetation and carbon pools in relation to atmospheric carbon dioxide concentration.pp151-187 in Australia's Renewable Resources, Sustainability and Global Change. Roger M. Gifford and Michele M. Barson (Eds) Publ Bureau of Rural Resources and CSIRO Division of Plant Industry. Quoted in "Pasture improvement for potential additional C-sinks for inclusion under the Kyoto Protocol", by Roger M. Gifford, Damian J. Barrett and Andrew Ash (with input from Miko Kirschbaum, John Donnelly, Richard Simpson and Mike Freer) for the Biosphere Working Group of the CSIRO Climate Change Research Program, 30 April, 1998*



reduction in soil organic carbon may remain until the end of the rotation."[38]

Plantation forests poor carbon performers: Tree farms are also a bad investment when it comes to storing carbon, when compared to the natural forest:: A study reported in New Forests concluded that: "An area covered with a plantation managed for maximum volume yield will normally contain substantially less carbon than the same area of unmanaged forest". [39] A similar study in Oregon found that a 450-year-old natural forest stored 2.2 to 2.3 times more carbon than a 60-year-old douglas fir plantation on a comparable site. [40]

Forests lose more C in a fire than soils: CSIRO team concluded that Carbon beneath pasture is safer from fire than that tied up in forests: "Sequestering carbon in soil organic matter has the attraction of being more secure from catastrophic loss, such as from wildfire, than is C in above ground tree biomass."[41]

Forests risk big fires in hotter, drier future: Large-scale die-offs from drought, fire, and disease outbreaks loom large in current ecological models of climate change and have the capacity to turn a

[38] John Turnera, Marcia J. Lambert and Dale W. Johnson, "Experience with patterns of change in soil carbon resulting from forest plantation establishment in eastern Australia", Forest Ecology and Management, Volume 220, Issues 1-3, 10 December 2005, Pages 259-269

[39] *Cannel (1999). Environmental impacts of forest monocultures: water use, acidification, wildlife conservation, and carbon storage. New Forests, 17: 239-262.*

[40] *Harmon M., 1990, Effects on carbon storage of conversion of old-growth forests to young forests. Science 247, pg.699-702*

[41] *Roger M. Gifford, Damian J. Barrett and Andrew Ash, Pasture improvement for potential additional C-sinks for inclusion under the Kyoto Protocol, Biosphere Working Group of the CSIRO Climate Change Research Program, 30 April, 1998*

carbon sink into a carbon source almost instantaneously. Direct carbon emissions from forest fires in Korea in 2000, for example, negated one to three percent of the global forest carbon uptake.[42]

Forests risk becoming emitters in Climate Change: Computer simulations carried out by Jing Ming Chen's research group at the University of Toronto reveal that, while China's forests sequestered 13% of the total CO2 absorbed by the world's forests during the 1990s, their model suggests a rather different picture a hundred years from now when the forests could even become net carbon emitters.[43]

Forests don't have sufficient capacity : We can't plant enough trees in the time we have left, and not all soils are suitable. The UK Department of Energy estimates that to offset the UK's total carbon dioxide emissions would require the planting of a new area of tropical forest about 1.5 times the size of the UK.[44] "We don't have enough land to make up for all our emissions; you would need seven planets," say Tim Cadman, a PhD candidate at the University of Tasmania who has spent years researching the forestry industry and government forest policy.[45]

The World Rainforest Movement claims that to compensate for the eight gigatonnes of carbon we currently release into the atmosphere every year would require planting four times the area of the United States with trees, never letting these trees die and decay thereafter. Millions of hectares of land would have to be taken over for carbon sequestration to have even a small impact on overall emissions.

Forests can cause global warming Ken Caldeira, a professor at the Carnegie Institution's Department of Global Ecology at Stanford University, caused a storm when he wrote in The New York Times : "The preservation and restoration of forests outside the tropics will do little or nothing to slow climate change and could even accelerate warming".[46] The "albedo effect" is the degree to which the Earth's surface reflects sunlight, and it differs markedly from place to place. He argues that, by adding trees in northern forests, we are effectively dampening local reflectivity. In winter, for example, smooth, highly reflective snowfields are swapped for a more broken, darker surface. The net result is extra heat. "The absorption of sunlight by boreal forests means they exert a net warming influence on global temperatures," he says. In other words, temperate forests don't cool the planet; they warm it.

Forests plunder water supplies: Plantation forests take substantial amounts of water out of river systems. A major IPCC study, synthesising more than 600 observations, and climate and economic modeling, was able to document substantial losses in stream flow, and increased soil salinization and acidification, with afforestation. Plantations decreased stream flow by 227 millimeters per year globally (52%), with 13% of streams drying completely for at least 1 year.[47]

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[42] *Choi, S.D., Y.S. Chang, and B.K Park. 2006. Increase in carbon emissions from forest fires after intensive reforestation and forest management programs. Science of the Total Environment, 372(1):225-235.*

[43] *Ju, W. et al. Future carbon balance of China's forests under climate change and increasing CO2. Journal of Environmental Management doi:10.1016/j.jenvman.2006.04.028*

[44] *UK DoE, 1991.*

[45] *SMH, 27 January, 2007*

[46] *Caldeira, K. "When being green raises the heat." The New York Times, January 16, 2007.*

[47] *Robert B. Jackson, Esteban G. Jobbágy, Roni Avissar, Somnath Baidya Roy, Damian J. Barrett, Charles W. Cook, Kathleen A. Farley, David C. le Maitre, Bruce A. McCarl, Brian C. Murray, "Trading Water for Carbon with Biological Carbon Sequestration", Science 23 December 2005*

Carbon Sinks & Sources

Carbon dioxide is one of the greenhouse gases contributing to global warming and climate change. When carbon is removed from the atmosphere and stored in the biosphere it is said to be “Sequestered”. Places where carbon is stored are called carbon “Sinks.” The opposite to a sink is a “Source” of Carbon Dioxide.

All living things are part of the carbon cycle. Carbon is continually turned over during the natural progression through birth, growth, death and decay. Some of the carbon atoms in our bodies at this moment would have been constituents of the plants, animals and soils present on earth many millions of years ago. People are around 18% carbon, wood is around 50% and the organic matter component of soils is around 58% carbon.

When people think ‘carbon’ they usually think ‘trees’, but in reality 75% of carbon in the terrestrial biosphere is in the soil. Healthy grasslands may contain over 100 times more carbon in the soil than on it, making a well managed perennial ‘grass ley’ the quickest and most effective way to restore degraded land. Billions of tons of organic carbon have been lost from agricultural soils – and continue to be lost - through inappropriate land management practices. For this and other reasons, agriculture is the second largest contributor to greenhouse gas emissions in Australia. The ‘standing energy’ industries such as coal-based electricity generation are the largest source.

Carbon Offsets

Carbon credits are a financial reward for activities that reduce the levels of carbon dioxide accumulating in the atmosphere. There are a large number of different carbon trading schemes in the world, some of which date back to as early as 1995. A ‘carbon trade’ can simply be an agreement between two parties. For the term ‘carbon credits’ to be used, the emission reduction or biosequestration to which the credits apply must be subject to verification by an accredited certificate provider.

One credit, as designated by an emission trading, emission reduction, renewable energy or abatement certificate, represents one tonne of carbon dioxide equivalent. Carbon credits for sequestration are a type of offset trade and the carbon storage may be leased or sold. Simply stated, the entity emitting the carbon buys registered certificates and the entity sequestering carbon sells them (ie receives money for carbon storage). A ‘trade’ occurs when carbon credits are secured and then surrendered or acquitted through an accredited carbon broker, carbon exchange or carbon registry.

The first government legislated carbon trade in NSW, valued at over one million dollars, was registered in March 2005, between Forests NSW and Energy Australia. The 'carbon credits' were for carbon sequestered in hardwood timber plantations in northern NSW. Trading in carbon is a multi-million dollar industry in Europe and the United States. Forecasters have suggested that carbon trading is poised to become the world's largest commodity market, generating financial innovation in hedge funds, futures and derivates. The volume of trade under the European Union's Emission Trading Scheme (EU-ETS) exceeded all expectations in the early part of 2005, leading to the recent launch of the European Climate Exchange (ECX), the world's first carbon futures market. Carbon emissions are a global problem and credits for both emission reduction and carbon sequestration are an important part of the global solution.

Organic carbon (such as humus) has many benefits in soils, making effective carbon management the key factor for productive farms, revitalised catchments and a greener planet. Carbon credits for regenerative land management would help to 'cash flow' the multiple natural resource management and environmental benefits that accompany increased levels of carbon in soils.

Soil Carbon Dynamics

Agricultural land's ability to store or sequester carbon depends on many factors including the following:

1. Climate – in cooler climates, decomposition happens more slowly, so the plant residue has a greater chance of becoming humus, which is a stable part of soil with high organic carbon content.
2. Soil type – poorly-drained soil types have the capacity to store carbon more readily than others.
3. Type of crop or vegetation cover – crops like wheat and

corn produce higher amounts of residue, i.e., more organic matter (and more carbon) is left after harvest. Warm season grasses in conservation buffers are more effective at storing carbon than cool season grasses. Making certain plant choices can help capture more carbon from the atmosphere and make it available to processes that may lead to longer-term storage.

4. Management practices – how producers manage their pasture or crop land is key to how much carbon can be stored. Most of the management practices that favor carbon sequestration also improve soil health, reduce erosion, and have other environmental benefits.

Farm Greenhouse Gas Emission Reduction

Carbon Offsets are only one aspect of Greenhouse Gas Emissions for Farms. Agriculture is the second largest emitter of GHG in Australia, according to the scientists. We may not have to pay for some emissions; we will know when the legislation is finalised.

The categories of emissions farm enterprises dominate are:

•Methane – from animals with a rumen or second stomache for digesting coarse materials;

•Nitrous Oxide – primarily from the application of nitrogenous fertilizers and from animals urinating;

•Carbon Dioxide – primarily from use of electric power and fuel for vehicles.

The Victorian DPI recommend the following action:

•Consult machinery maintenance manuals, Better Fertiliser Use pamphlets from DPI, MLA, Fertiliser course notes, Best practices from www.nitrogen.unimelb.edu.au

•Actions include choosing types & timing of fertiliser, especially nitrogen applications, and those selecting breeding stock

• Commit to: Most fuel-efficient equipment use:

- update to more fuel-efficient, lower-emission combustion engines
- maintain maximum machinery operating efficiency, by regular maintenance to at least manufacturer's minimum intervals and recommendations (e.g. emission control checks, tune-ups, fuel systems cleaning, filter & oil changes)
- use least horsepower-rated equipment for the purpose (e.g. use an ATV, or ute rather than tractor)
- reduce percentage of start and warm up emissions in total emission from combustion motors, by saving up tasks until machine operating period is at least 20 minutes

Fertiliser Management

Best practice nitrogenous fertiliser management:

- choose fertiliser containing ammonia instead of nitrates
- avoiding applying nitrogenous fertiliser when soils are warm and/or waterlogged
- avoid applications of nitrogenous fertilisers to non-north-facing slopes during warmer seasons
- apply nitrogenous fertilisers only when rye plants are at least 2-leaf stage, cocksfoot at 3-leaf

Methane Management

Best practice nitrogenous fertiliser management:

-decrease age of breeding herd

-reduce stocking rate

- select & cull cattle to improve herd's feed conversion efficiency
- match energy to protein in feed throughout all seasons
- add small quantities of black wattle bark(tannin), in water or meal, during spring & winter
- provide access to black wattle plants for light grazing
- add small quantities of unsaturated oils to feed in summer
- choose feed additive oil sources that are waste or byproducts, over prime production

Monitoring required:

- Feed conversion records for herd lines.
- Potential sites for waterlogging, pugging.
- Fertiliser needs, use and results
- How well contractors are following instructions

Records kept:

- Annual estimates of farm emissions for activity segments (e.g. fertiliser, energy, fuels)
- Soil tests & carbon level changes
- Fertiliser applications, components, rates, dates of application, conditions during application
- Terminal animals' weight gains from birth to kill

Growing soy beans on the rangelands?

Those who argue that we should substitute grain crops for grazing to reduce methane emissions from cattle and sheep don't understand realities in the food production industries. In many countries, the greatest proportion of agricultural land is unsuitable for growing crops and grazing is the only option for producing food in these areas. Scientific American reported on 28 December, 2011 that "a lifecycle analysis conducted by the Environmental Working Group that took into account the production and distribution of 20 common agricultural products found that red meat such as beef and lamb is responsible for 10 to 40 times as many greenhouse gas emissions as common vegetables and grains." This simplistic analysis is also uninformed by the contribution animals can make to a cropping operation as four-legged composting units

Wake up and smell the manure

Australia's dairy farmers have been given a cold shower on Climate Change by Dairy Australia. "It doesn't matter if you believe in Climate Change or not, because it is now a major political and social force that is and will continue to impact on all industries, including dairy," it says on its website. Many in the farm community have been convinced by those who deny the science of Climate Change. "The physical reality of Climate Change remains is still debatable for some. This will continue to be the case because it is very hard to differentiate small changes to the average climate from the background of large and poorly understood climate variability. However, 'belief' in Climate Change is no longer relevant because the very idea of Climate Change, backed up by clearly more volatile weather events, has created its own, overwhelming social and economic momentum. 'Climate Change' is fundamentally changing everything from the behaviour of Governments to consumer choices. It has become one of the critical lenses through which every decision must pass – how individuals and industries react will fundamentally their future resilience and competitive advantage." This approach is in contrast to the hysterical response of industry bodies to the Price on Carbon. "Dairy farm families will be slugged $4200 by the Carbon Tax, says ABARES" This is how the media reported it, but ABARES said nothing like it in its report "Possible short-run effects of a carbon pricing scheme on Australian agriculture". This is the worst case scenario. It is based on processors passing on 100% of their cost increases to farmers, which they can't and won't do, according to Fonterra, one of the biggest. Before both processors and farmers take action to reduce their electricity usage, the impact could be as low as just over $1000, says the ABARES report. "In most cases, any cost increases from a carbon pricing scheme will be shared along the supply chain between farmers, processors, wholesalers and retailers, exporters and final consumers," it says. Fonterra confirmed this in October 2011 when general manager for sustainability Francois Joubert said the company will wear its

own increased power costs as best it can, without passing those on to suppliers. "It's increasingly difficult for us to pass costs on to our markets, to our customers; it's also difficult to pass costs on to our suppliers. We are in a very competitive milk supply environment and so therefore it's our job to mitigate increased costs within the business and that's our intention."

Cutting dairy costs

There are many opportunities for dairy enterprises to reduce energy consumption. Heating and cooling are major energy cost centres, and one farmer reports reducing these costs by 30% following the advice in a report published by Fonterra: What Does A Carbon Price Mean For You? In it the company lists many ways to save electricity costs.

Milk cooling

• Insulate the vat, pipes and spaces underneath the vat
• Check and repair any leaks in refrigeration system
• Pre-cool milk as much as possible before placing into milk vat
• Monitor plate cooler performance by checking actual milk temperature against set point temperature and ensure it is sized correctly for milk flow
• Check pre-cooler inlet filter and water flow to ensure volume is adequate and constant
• Check and clean the fins on condensing unit of refrigeration plant and ensure good airflow around the unit
• Service the plate cooler and refrigeration unit regularly – at least annually
• Consider the source of pre-cooler water and whether it is cold enough.

Cleaning systems

• Talk to your supplier about new cleaning technologies and chemical improvements.
• Install heat and chemical recovery systems.

Lighting

• Use energy efficient globes
• Turn off lights when not in use – use natural light when possible
• Repair defective light fittings
• Install automatic light sensors if suitable
• Consider installing low watt fluorescent lights.

Water and effluent pumps

• Although water management and pumping technology is often automated, significant electricity savings can be made by checking this equipment
• Check there are no leaks or pressure loss points
• Choose appropriately sized hoses and nozzles to minimise wash down time
• Size pipes correctly to capacity of pumps

• Install the most energy efficient pump available.

Vacuum pumps

• Only run the vacuum pump when needed
• Check belts and pulleys are correctly tensioned and any replacements match
• Install a Variable Speed Drive (VSD) linked to your motor's vacuum requirements
• Rotary vanes or lobe pumps with variable speed drives may also be suitable replacements for a water ring pump
• Look for the most energy efficient model available.

Energy sourcing

• Shop around for the best priced electricity supplier. You could make significant savings just by asking your current supplier or changing retailers
• Use off-peak power when possible
• Consider solar, wind and other alternative energy sources if available in your area.

Water heating

• Consider solar or gas water systems to heat or pre-heat water
• Heat water only when required – not all day and night
• Check water is not boiling in the cylinder
• Check thermostat settings monthly to ensure good performance
• Compare the temperature of the outlet water with the thermostat to ensure water is not overheated
• Regularly check the element anodes for corrosion – replace if needed
• Regularly check the pipe and cylinder for leaks – repair or replace if required
• Insulate the hot water system (both cylinder and discharge lines)
• Size all systems to appropriate load size and minimise unused capacity
• Install heat recovery equipment to capture heat generated by milk refrigeration systems. Examples of such heat exchange systems have cut heating and cooling costs by 30 per cent.

Pig farmers to earn credits for manure

Australian pork producers have been cleared to start earning Carbon Credits by cutting emissions from manure. They can also slash their power costs by turning the emissions into fuel. Capturing methane at the point of release, farmers can burn it by ‘flaring’ or they can go further and use it to provide on-farm energy to run equipment and heating. Burning Methane (CH4) produces CO2 that is emitted instead. Methane has 24 times the Global Warming Potential of Carbon Dioxide. The farmer earns 24 tonnes of CO2 offsets for every tonne of Methane captured and burned. The manure management methodology that makes these opportunities possible is the first released under the Carbon Farming Initiative and was launched yesterday by , Agriculture Minister Joe Ludwig and Parliamentary Secretary for Climate Change and Energy Efficiency Mark Dreyfus. The project involves retrofitting an impermeable cover and sludge management system to an existing unheated anaerobic pond at a southern Queensland breeder unit piggery. The cost of installing basic methane capture infrastructure is likely to range from around $75,000 to $200,000 depending on the size of the piggery. The Australian pork industry suggests that by using the methodology, producers could increase the return on each finished carcass by around $3.45. Preliminary trials suggest the payback period for this infrastructure ranges from 18 months to five years in smaller operations. 680 commercial piggery operations in Australia stand to benefit from the CFI via this process. A trial was conducted at a piggery in Grantham in Queensland. Project manager Alan Skerman said the methane released from ponds of swine waste could be used not only to heat a piggery's sheds, but also to create usable energy through an electrical generator. "There's the potential there to reduce the farm's use of LPG by about half, substituting biogas for the LPG that's used for heating the piggery sheds," he said. "As well as those financial benefits, the owner can get extra income through carbon credits…. But there's the potential for the widespread roll-out of this technology in the pig industry." The methodology was developed in collaboration with the Australian Government, the pork industry and Queensland DPI scientists, and assessed by the independent Domestic Offsets Integrity Committee..

Carbon Farmers of Australia have a soil carbon sequestration methodology before the Committee which could deliver benefits to 130,000 Australian farmers.

22 ways to go low N_20

Managing Nitrogen emissions should be low-hanging fruit for farm offsets.

The Carbon Farming Initiative has two categories of offsets for N management: fertilizer management and manure management. The N2O Network (www.n2o.net.au) tells us that N_2O is a powerful GHG, 296 times more potent than carbon dioxide (CO_2). It stays in the atmosphere for up to 114 years. Mitigating N_2O represents an opportunity to reduce the greenhouse effect from anthropogenic emissions from agriculture. In 2007, Australian N_2O emissions from agricultural soils were estimated at 20.2 million tonnes of "carbon dioxide equivalent" or 85.9% of all anthropogenic N_2O emissions. Between 1990 and 2007, N_2O emissions in Australia rose by 24% and this increase is largely attributable to the increased application of nitrogenous fertilisers[1]. The Victorian DPI and Melbourne University scientists estimate that 60% of nitrogen inputs are lost from grazing systems. Nitrous oxide (N_2O) gas is emitted naturally from the microbial processes of nitrification and denitrification in the soil. The use of nitrogenous fertilisers, and the return of animal dung and urine, increases the soil content in mineral nitrogen. In turn, this increases the rate at which bacteria release N_2O.

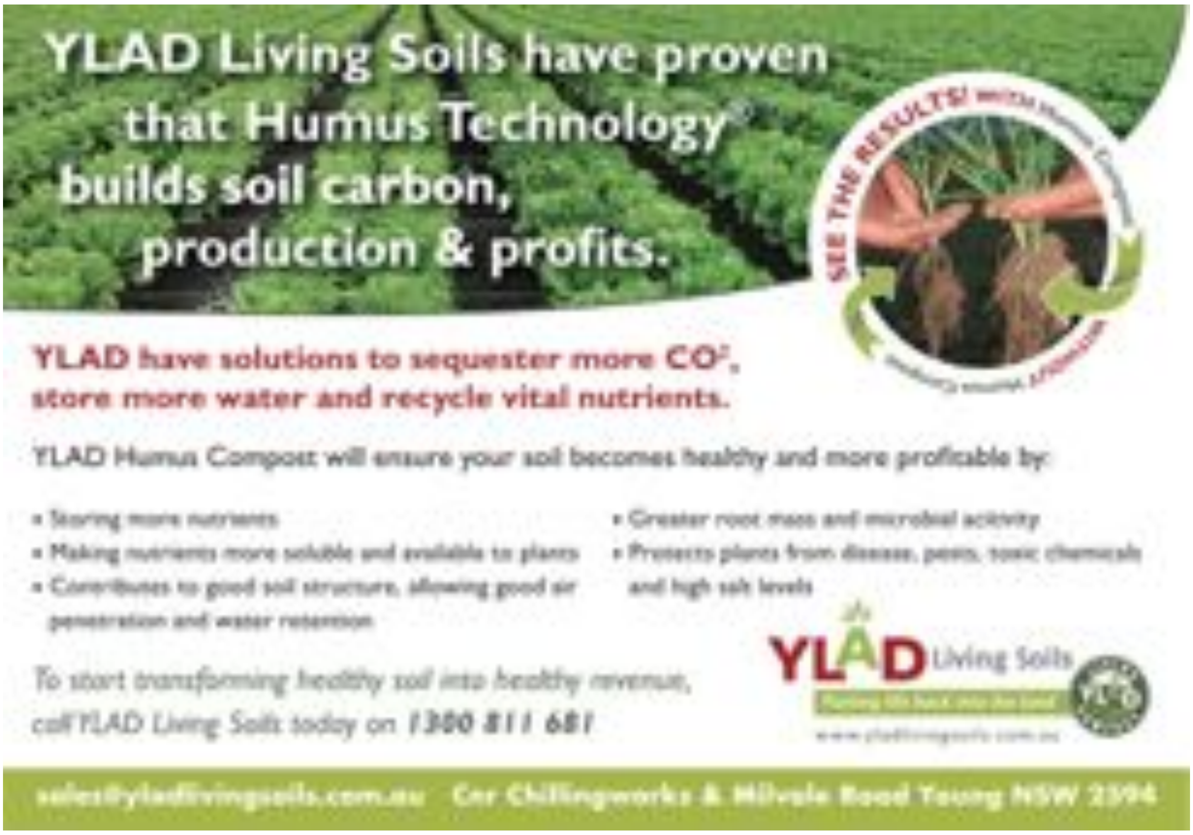
Here are 22 ways to limit N2O emissions, courtesy of the Victorian DPI:

ONE: Manage soil structure to maximise plant uptake and minimise nitrogen loss: TWO: Manage soil structure to maximise water infiltration but minimise waterlogging and leaching (need to be particularly careful on poorly structured sodic clay soils and sands).Gypsum can be used on most soils to improve soil structure and help avoid anaerobic conditions .

THREE: Manage cropping to protect soil structure: Avoid burning crop residues after harvest and retain where practical (e.g. prunings, stubble). Adopt conservation tillage and controlled traffic practices in broadacre cropping where practical. If cultivation is absolutely necessary, do not till the soil if it is excessively wet. FOUR: Aim to build soil organic matter—for example through including legume pasture rotations, minimum tillage or adding composted material FIVE: Ensure continuous plant cover where possible (e.g. between growing seasons and between row crops) to utilise available nitrogen and avoid losses of nitrogen by leaching or denitrification during the fallow. SIX: Place fertilisers carefully: Avoid application of fertilisers (especially nitrate) to waterlogged soils. Incorporate fertiliser at the top of raised beds or ridges to avoid wet areas. Place fertiliser below the soil surface where possible to limit ammonia volatilis-ation (especially on alkaline soils). Apply nitrogen fertiliser based on a calculation of target yield and crop nitrogen requirement over the growing season. SEVEN: Match nitrogen supply to crop demand - use soil or plant testing to assess available nitrogen supply to decide the quantity of fertiliser to apply. EIGHT: If available, use decision support tools (e.g. Yield Prophet in Grains) and seasonal forecasts for more timely and calibrated fertiliser decision support. NINE: Time fertiliser application to minimise loss via denitrification or volatilisation (for example if topdressing urea apply before rainfall or irrigation.) TEN: Crop demand for nitrogen is usually greatest during early spring, so apply nitrogen fertiliser when the crop needs it, rather than earlier in the season (when there is a greater probability of losses).

ELEVEN: Significant amounts of greenhouse gases can be generated from legume derived soil nitrogen as well as from fertilisers. Large amounts of nitrogen can build up in the soil (via mineralisation) following a pasture legume (or pulse crop) phase and this N is especially susceptible to losses following tillage under wet conditions. TWELVE: Avoid high rates of nitrogen in any single application.

The Victorian DPI tells us that 70% to 95% of nitrogen consumed by ruminants is excreted, SO:…THIRTEEN: Manage livestock waste to minimise emissions of greenhouse gases. FOURTEEN: Provide livestock with improved pastures, high-quality hay and silage, and grain-based supplements to improve the digestibility and balance the protein to energy ratio of rations. FIFTEEN: Formulate rations to maximise digestibility and minimise nutrient excretion (especially energy to protein), possibly with use of ration formulation models and/or mass balance models .SIXTEEN: Design feeding systems that reduce spillage and spoiling and maximise feed usage. SEVENTEEN: Monitor feeding areas to ensure that feed is not supplied in excess of animal requirements. EIGHTEEN: Avoid applying slurries or manure to land in wet conditions, such as wet winter soils. NINETEEN: Apply nutrients (i.e. manure) based on an assessment of crop or pasture requirements and a known N content of the effluent.TWENTY: Manage stockpiles, for example through composting, to avoid anaerobic conditions TWENTY-ONE: De-water storage ponds, for example by irrigation to crops or pastures to reduce anaerobic conditions TWENTY-TWO: For larger feedlots, consider covering anaerobic ponds to trap biogas for use in heat or electricity generation.



How To Calculate Soil Carbon Credits

Dr Christine Jones, who singlehanded created the issue of soil carbon trading in Australia – which leads the world in Carbon Farming techniques – gave us our first lesson in calculating Soil Carbon Credits when she explained how to convert science into a market mechanism.

The Fundamentals of Soil Carbon are as follows: Its volume in the soil can be expressed as: percent of the soil or a concentration (%) or a tonnage or stock (t/ha). To convert from one to the other unit of measurement, you need to know 1. The depth of core sample measurement and 2. soil bulk density.

Bulk Density (BD) is the weight (g) of one cubic centimetre (cm^3) of dry soil. When the soil is more compact, BD is higher. It ususally gets higher as you sample deeper. You need to know the BD to calculate the tonnage when you have a percentage carbon.

Remember: we grow percentages of Carbon and we sell tonnes of CO2. A tonne of carbon becomes 3.67 tonnes of carbon dioxide (CO_2).

"CO2-equivalent" (expressed as CO2e) stands for a single unit of 'currency' that covers other Greenhouse Gases like Methane (CH4) or Nitrous Oxide (N2O) – Methane is 24 times the Global Warming Intensity of CO2 and Nitrous Oxide is around 300 times more potent than a molecule of CO2.

Calculating Tonnages of Carbon andCO2

	Soil bulk density (g/cm^3)				
Soil depth	1.0	1.2	1.4	1.6	1.8
0-10 cm	10 (37)	12 (44)	14 (51)	16 (59)	18 (66)
0-20 cm	20 (74)	24 (88)	28 (103)	32 (117)	36 (132)
0-30 cm	30 (110)	36 (132)	42 (154)	48 (176)	54 (198)

TABLE 1. Christine Jones provides this guide to changes in the stock of soil carbon (tC/ha) for each 1% change in measured organic carbon (OC) status for a range of soil bulk densities and measurement depths. Numbers in brackets represent tCO_2 equivalent.

Using the Model

Assuming you have a 1% increase in soil carbon and the lab says you have a Bulk Density of 1.4, and the core sample was 10cms deep, you have 14 tonnes of carbon in each hectare or 51 tonnes of CO2e. If the price of CO2 is $25/tonne – a range of prices have been floated in debates, from $5 to $40, so $25 is chosen for an example – the return would be $1275/ha. AT $5/t the return would still be $255/ha. That still translates to more than $50,000 over 200ha.

(Caution: Carbon farming is not a get-rich-quick scheme. It can take many years to add 1% carbon. When it is captured you must then retain the soil at that level of carbon for the agreed length of time. Carbon credits are only paid when additional carbon is added to the soil.)

Christine Jones says that this is not difficult with regenerative regimes in which new topsoil is being formed. "Biological activity is concentrated in the top 10cm of most agricultural soils, but regenerative practices rapidly expand this activity zone to 30 cm and deeper."

Healthy soils are a reward in themselves. Most Australian soils have lost vast amounts of organic carbon, and this process can be reversed. Landholders would respond to the reward of carbon credits and change their soil management practices.

"Any farming practice that improves soil structure is building soil carbon," says Dr Jones.

…………

*This item is based on a paper delivered by Dr Jones at the YLAD Living Soils Seminars in February 2006.

YLAD Living Soils
Putting life back into the land

SOIL CARBON OPTIMISATION TOOL

A Simple Farm Planning Tool For Managing Water, Soil, and Vegetation Together To Increase Soil Carbon Sequestration.

"If all you hold in your hand is a hammer, everything looks like a nail."

ADDITIONAL BENEFITS

Holds Water In Landscape
Increased Ground Cover
Reduced Soil Loss
Improved Soil Structure
Increased Soil Fertility
Reduced Soil Salinity
More Vegetation
Healthier Vegetation
Increased Biodiversity

Return of Native Species
Greater Landscape Resilience
More Active Microbes
Reduced Artificial Inputs
Healthier Farm Produce
Healthier Consumers
Revenue From Tradable Offsets
Healthier Rural Economies
Stronger Rural Communities

A Water, Vegetation, and Soil-based Carbon Optimisation Tool

The SOIL CARBON OPTIMISATION TOOL (SCOT) is a simple system that can help land managers make decisions that will lead to farm landscape regeneration. It is easy to be confused by the options for emergency response to soil degradation and water management. SCOT can be used to sort through these options and choose which steps to take towards meeting goals. *SCOT is Solution Neutral. It favours no technique or system.*

The light bulb in the centre circle represents the fact that many Farmers and Graziers use a management system to help them make decisions. *SCOT* does not seek to replace them. Instead it can be incorporated into the process. It is a flexible system.

SCOT divides Farming into subject areas. On the Rings can be found the Foundations of Carbon Farming:

1. Water
2. Vegetation
3. Soil
4. Land
5. Microbes (or Biology)

These Foundations are equal in importance. Each is an area of focus and an area of activity. There is a time to think of them on their own, and a time to think about the way they relate to each other.

This device has many uses:

The Planner can be a CHECK LIST for a CARBON FARMING AUDIT. Each level is a Heading and a list of options. (Not all options are listed on the rings. A list can be supplied.) The Carbon Farmer can use it to find options that they haven't heard or thought of before.

The Principle of "One To Many" Options simply reflects the fact that, in the inner rings (especially water systems) the likelihood is that more than one option would not be chosen.

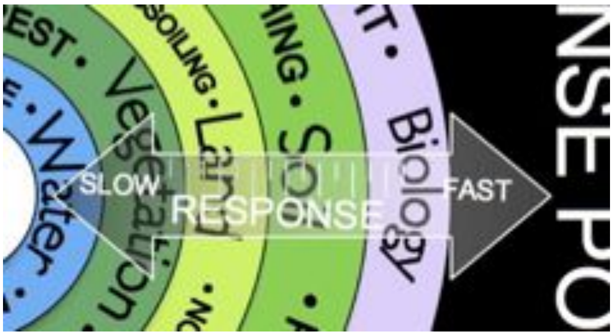
SCOT can be a TEMPLATE for a CARBON FARM PLAN. If you start at the centre and move outwards, you are following a path that deals with major decisions which form a platform for all other activities before leading on to less fundamental options. Moving through the rings, we ask the Planning Questions:

Q.1. Is this option relevant to this property and this landscape?

Q.2. What Return On Investment can we expect? (Is it low hanging fruit - fast, cheap, and easy to install? Or will it cost more than it is worth?)

Q.3. Does it get a tick in every box - if working on a triple bottom line: financial, environmental, and social impact.

Q.4. Do we face a trade off between one goal and another if we introduce this option?



SCOT can also be used to estimate likely carbon accumulation response times, based on that conventional science that can be relied upon to be accurate and fair, plus the experience of Farmers in the field, whichever is deemed the most credible. Eg. inoculating with probiotics can have rapid results (and not necessarily all labile, either) whereas relying soley on grazing management can see 5 to 7 years pass before results appear.

SCOT can be a PORTFOLIO PLANNING TOOL. This means selecting complementary options and combining them. Soil Carbon Sequestration requires 'change in land management'. Usually a single change is introduced. (Eg., grazing management.) This change can create a new 'disequilibrium'- or carbon growth stage – which can take 20-30 years to reach 'equilibrium' or saturation. But in in view of the crisis in climate patterns, the faster we can reverse the damage of centuries of natural systems degradation the better.

The Planner can be used as an IMPLEMENTATION PLAN GUIDE. Eg., The order of installation of options might be important. For instance, a laser graded water solution might deplete soil microbial stocks disturbed by machinery. Whereas a decision to use a biofert can be taken at any time without major implications for other decisions.

The degree of disruption to normal operations and practices can also be determined by the Rings.

SCOT can be a RISK MANAGEMENT GUIDE. If the Farmer wants to put a toe in the water, start on the outer rings and move in towards the centre. If you want to jump in boots and all, start at the centre and move outwards. You are now following a path that deals with major decisions which could be hard to reverse, before leading on to less risky options.

Used in this way, SCOT represents a "Hierarchy of Permanence" - running from more to less permanent as you move from the centre ring outwards.

SCOT as an EDUCATIONAL AID. By working through the rings and the planning process, a Trainer can lead a class to discover the individual parts of a system and the way they can be incorporated into a Farm Plan. How they can be deployed in 'teams' to maximise their impact. And how they can be changed over time.

The SOIL CARBON OPTIMISATION TOOL is the centrepiece of the training programs offered by Carbon Farmers of Australia (CFA). This is the trading arm of the Carbon Coalition.) CFA offers Carbon Farming and Soil Carbon training in programs ranging from 1 hour to two-day workshops. CFA's "Carbon Farming 101" program is a half-day introduction to Carbon Farming. "Carbon Farming 101" is being offered as a half day "Come Up To Speed Before The Carbon Farming Conference & Expo" on 25th October, 2010 at the Dubbo Civic Centre.

The Soil Carbon Credit creates the greatest opportunity to transition the great mass of conventional land managers into Regenerative Farmers to achieve the critical mass across the millions of hectares needed to reach the sequestration targets. Farmers understand price signals.

SCOT Carbon Farming Practices Glossary

The following is a short list of Carbon Farming practices – there are many more to be recorded.

Carbon Farming – any land management technique (or combination) that aims to sequester carbon in soils for whatever reason.

Holistic Management - a systematic method for making decisions about any shared resource; identified with 'planned grazing'.

Natural Sequence Farming – a system for managing water in the landscape that seeks to replicate the native irrigation system that operated before white settlement.

Keyline Planning – a system of water engineering and subsoil ploughing that aims to restore farm landscapes and soil health.

Planned Grazing - known in the past as cell grazing, time controlled grazing, or rotational grazing, it has elements of each. Planned grazing involves planning the access of grazing animals to pasture based on the amount of time the vegetation needs to recover and grow a full compliment of 'solar panels' (blades of grass).

No-Till – a cultivation technique that reduces disturbance of the soil. Can be known as 'direct drill'. Can involve heavy use of herbicide. 'NoKill' variant uses no herbicide.

Pasture Cropping – direct drilling a cereal into a dormant perennial pasture to renovate pasture. Less emphasis on yield.

Perennial Cover Cropping – the reverse of pasture cropping. A perennial sward is kept covering the soil during old fallow time. Crop planted into sward.

Biological Farming – the name has been used by one of the two major organic certification standards in Australia; also the name used by the biofertiliser industry for a soil-biology-focussed farming approach –

using compost teas, minerals, .etc.

Biodynamic Agriculture – known mainly for composting process involving on-farm manure placed in cow horns and buried for 12 months, then used to in a naturopathic style to produce a spray-on liquid.

Organic Agriculture - growers are certified as running a toxic chemical free operation. Soil disturbance by ploughing allowed.

Probiotic Inoculants – Inoculants that contain microbial mixes selected for conditions and objectives. Sprayed onto vegetation.

Mulching – a soil repair technique using any suitable material to protect soil from heat and conserve water

Green Mulching – any crop grown to be ploughed in to soil to increase soil organic matter.

Composting – converting raw biomass into plant-available organic matter.

Compost Teas – tea-like solution created by determining microbe mix in composting process and steeping water in the mix; some operators use flow form structures to energise the water/teas before application.

Dung Beetles - introduced species of dung dessicators which roll balls of mainly cow manure into holes and transport it metres down into the soil profile.

Forestry – grassy woodlands, shelter belts, wldlife corridors, and plantations are all options tha can be used to increase soil carbon.

This Publication was made possible by the generous support of

Best ENVIRONMENTAL TECHNOLOGIES

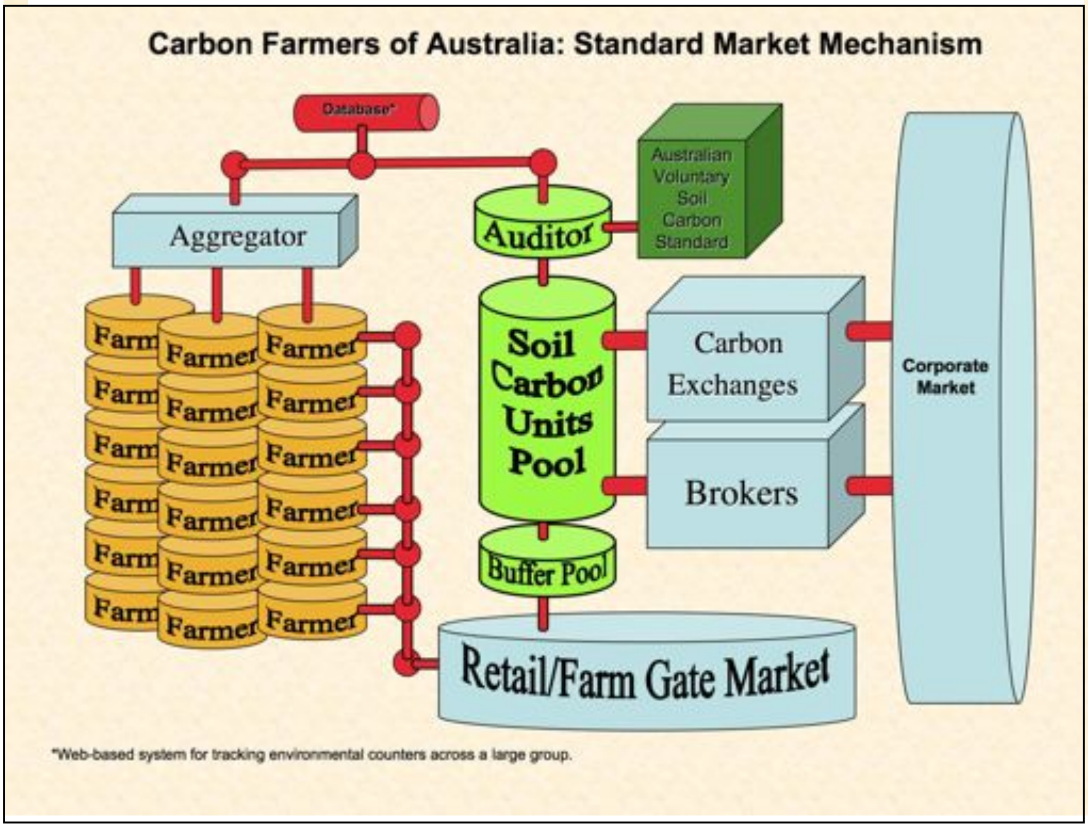
What is a Carbon Offset?

The World – in the gathering known as the United Nations – agreed to act together to slow the progress of Global Warming any way it could while we adapted to Climate Change. Most of the world's credible climate scientists agreed that Carbon Dioxide concentrations in the atmosphere were the likely cause of an increase in the global mean temperature. The result of this increase would be more frequent and more severe weather events, including droughts and floods. The nations of the world decided to use an American concept called 'cap and trade' that had been used successfully in the 1980s to overcome acid rain by reducing emissions of sulfur dioxide. Rather than expect businesses to cease emissions immediately, Cap and Trade sets targets to achieve by certain dates, stepping down emissions by stages. This transition to a low carbon economy will require major shifts in technology in energy generation – from burning coal and oil (hence the campaign of Climate Change denial funded by fossil fuel companies) to using renewable sources such as solar and wind and low polluting sources such as nuclear power. It would disrupt industrial economies too much to try and make the change all at once. So Cap and Trade allows companies to make reductions within their existing operations in the early stages while incorporating investment in low-emissions technology in the long term. To encourage them to make the shift, they are able to meet the gap between reductions they can easily make and their Cap by buying "offsets". A Carbon Offset is a measured reduction in emissions in one place made to compensate for emissions made in another. It can also be a measured removal of CO2 from the atmosphere by carbon sequestration. To encourage companies to make the investment in low emissions technology, the Cap is set lower and lower with each stage, making it harder for them to simply buy their way out.

COMPLIANCE MARKET VS VOLUNTARY MARKET

The Compliance Market is the place where emitters can purchase offsets to meet their targets set under a Cap and Trade system. The Voluntary Market is the place where companies or families or individuals wanting to become carbon neutral can buy offsets equal to their entire emissions. Hence the word "Voluntary". Prices are often higher on the Compliance Market because the number of credits or permits is always less than required – as a motivation to emitters to move as quickly as possible to low emissions technologies. On the other hand, voluntary offsets are usually available in unlimited numbers.

How does ‘the market’ work?



The Carbon Offsets Market is new and has unique features. Here we explain how it works.

Commodity: Carbon is bought and sold like any other commodity. Offsets trading takes place in tonnes of CO2~e. The ‘~e’ stands for ‘equivalent’. This means that trade in five different Greenhouse Gases, including Carbon Dioxide, Nitrous Oxide and Methane, takes place in units of CO2. The ‘equivalence’ is measured in Global Warming Intensity: a tonne of Methane is 24 times as ‘warming’ as a tonne of CO2. N2O is 294 times as “intense”. Commodity markets have a range of roles played by different people. Each role is essential.

Growers – The smallest trading unit for offsets, depending on the market, is between 10,000 and 25,000 tonnes of CO2~e. Few growers could fill an order on their own. Growers are normally aggregated into groups for purposes of sales. They are also pooled in large numbers to spread risk by building a buffer against losses.

Aggregator – An Aggregator gathers the output of individual growers into tradable amounts. Organisations with memberships could perform the role. The aggregator could be responsible for baseline measurement, engaging an independent sampler and laboratory. The Aggregator in many cases is responsible for feeding data into the database/register, staying in touch with Growers, providing information, etc.

Register/Database – Each unit (tonne) traded has an individual identification number which follows it wherever it goes. It is traceable to avoid the possibility of being double sold. In Australia, the Government is establishing a Register.

Auditor – Carbon must not only be measured; it must also be verified. Professional independent environmental auditors will be required in all regions. They will police the various standards authorized for trading under the wide range of programs expected to be launched on the market.

Program Proponents – To be able to trade, a Grower must have access to a "Methodology" which set down what they must do to earn the offset. These methodologies can theoretically be put forward by a farmer. But they can be complex and are normally created by specialists at designing market mechanisms.

Brokers - As with other farm commodities, the Carbon Market needs brokers to give Growers access to buyers in the corporate/compliance market and the corporate/brand and consumer/retail markets. Brokerage fees will be one element in a competitive market of middlemen seeking the Grower's business.

Buyers – The compliance buyer is purchasing to meet their cap and trade liabilities. They are corporations who might use the fact that they buy offsets that support farmers and farmland restoration in their public image communications. The voluntary 'retail' market buyer is a consumer who might buy 2 tonnes to offset an air flight to the USA. The "farm gate"market is ideally a consumer who wish to offset their own emissions at home and discovered the Grower via a farmstay or a farmers' market.

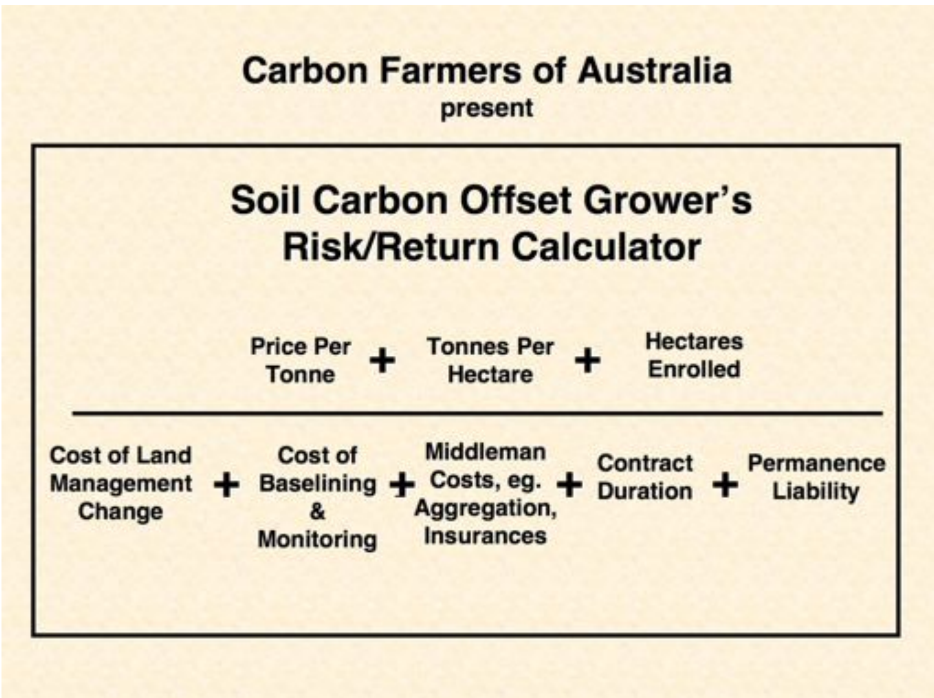
YLAD Living Soils
Putting life back into the land

How to weigh up a Soil Carbon Offset Proposal

Most comment on farm offsets trading has focussed on “price” of a tonne of CO2. But, as the Soil Carbon Offsets Grower’s Risk/Return Calculator reveals, there are several other pieces of the puzzle that need to be considered before a Grower can have a clear view of the value of the proposition they might be offered.

Price Per Tonne can be less relevant when seen in context of the volume of tonnes grown – seen when you calculate the tonnes per hectare and the number of hectares enrolled. The picture improves even more when you calculate the number of tonnes of CO2 represented by your sequestered Carbon. (Remember we grow Carbon and we sell CO2. Multiply tonnes of Carbon by 1.67 to see your tradable tones of CO2.

Below the line you must calculate the cost of changing your management practices (eg. wire and water for grazing management, etc.) The cost of baselining your soil carbon plus the ongoing monitoring must be included. Middleman costs can be between 10% and 30%. The duration of the contract is an important factor, closely related to the Permanence liability. The latter could be estimated via a net present value calculation.



What's in the Carbon Farming Initiative for you?

In 2006, when the Carbon Coalition started campaigning for farm-based carbon credits, the Australian Greenhouse Office believed that farmers would be forced to reduce emissions from animals and cropping or pay for offsets. They assumed that, because Agriculture was the second-biggest emitter of Greenhouse Gasses, farmers would have to pay. And they were certain there could be no credits for soil carbon captured and stored because there was no scientific proof of it. By 2009 PM Kevin Rudd instructed his Minister For Agriculture to look into soil carbon. By early 2010 Minister Tony Burke told farmers that there would be no 'fart tax' or methane bill and there would be no nitrogen fertilizer tax. He said that Agriculture was…"The only section of the Australian economy where we ignore the emissions, ignore them completely. Even if they go up, we ignore them… But if you're able to reduce your emissions through abatement, you get cash." And farmers who store carbon in soils and vegetation also get cash. In August, 2010, PM Julia Gillard announced the Carbon Farming Initiative: "Farmers and landholders will benefit from a new income stream… the Government [will] legislate clear rules for the recognition of carbon credits." The Government released draft legisation in December 2010. The Carbon Credits (Carbon Farming Initiative) Bill became law in August 2011. It has the support of both sides of politics.

Did Agriculture 'Dodge a Bullet'?

The Carbon Price Mechanism Scheme completely ignores the direct emissions released on farms by farm practices. This is despite the fact that Agriculture contributes 15% of Australia's overall emissions. Since the Government ratified the Kyoto Agreement, Australia is now liable to reduce its emissions to meet targets or pay a penalty in the form of offsets that can neutralize the emissions we failed to avoid.

By contrast, farmers in New Zealand will be forced to report and reduce their emissions to meet targets or pay the same penalty.

Australian farmers have been expressly protected from liability for their emissions from the following farm activities:

- methane from the digestive tract of livestock;
- methane from rice growing;
- methane or nitrous oxide from urine and dung;
- methane and nitrous oxide from burning savannas and grasslands;
- methane and nitrous oxide from burning stubble or crop residue;
- methane and nitrous oxide from burning sugar cane before harvesting;
- carbon dioxide or methane or nitrous oxide emitted from soils;
- emissions from carbon sequestered in vegetation and other biomass or decaying organic matter or soil;
- emissions from carbon sequestered in vegetation caused by land clearing or forestry.

Offroad fuel use for transportation for agriculture is also exempted.

Farmers will be faced with meeting pass-through cost from energy-intensive processors, heavy transport, electricity generation and waste disposal.

Why is the Government doing this?

The Government's change of heart is not hard to understand when you look at the facts:

1. Agriculture as an industry was on its knees after 10 years of devastating drought when this turnaround occurred. Climate Change "taxes" would cause the industry damage.
2. The changes to soil management that are required for carbon sequestration are the same required for building a buffer against Climate Change. The Government would have to spend a lot to convince farmers to make these changes anyway.
3. By choosing to set a price oncarbon and allow a market form has the effect of getting polluters to pay for the changes needed.
4. The profit motive will reduce the need for expensive extension services running expensive programs to encourage change.
5. Food Security and Regional Conflict over Access to Resources is driving many international organizations to press the case for soil sequestration. Instead of reducing the capacity of the industry by imposing new taxes, the Australian Government has chosen to improve Agriculture's profitability.The Government's Carbon Farming Initiative (CFI), announced on 14 August, 2010, aims to give farmers, landholders and forest owners access to domestic and international carbon markets.

There are many opportunities for farmers and landholders in the CFI. They can earn offsets from a long list of activities, including:

- reforestation and revegetation – eg. plantations, integrated farm forestry and regrowth;
- reduced methane emissions from livestock – eg. diet management, rumen inoculants, etc.;
- reduced fertiliser emissions – eg. precision application, alternative fertilizers, etc.;
- manure management – eg. composting, anaerobic digesters and flaring;
- reduced emissions and/or increased sequestration in agricultural soils (soil carbon) – eg. no-till cultivation, grazing management, pasture cropping, nutrient management;
- savanna fire management –eg. avoiding large destructive fires

while retaining environmentally-positive use of fire;

• avoided deforestation – eg. reduced land clearing;

• burning of stubble/crop residue - eg. stubble retention/incorporated, etc.;

• reduced emissions from rice cultivation – eg. reducing water levels in paddies to reduce methane emissions;

• reduced emissions from landfill waste – eg. composting, applying compost on soils.

Carbon Farmers of Australia recommend that Farmers decide which of the activities on this list are relevant to them and take a portfolio approach to them: Revenue from offsets will be maximized and opportunities won't be missed. A typical 'portfolio' of activities could include fertilizer reduction/ substitution + reduced methane from livestock + reduced landfill/ farm composting + soil carbon sequestration.

While the scheme started on 1 July, 2011, not all the options are ready. The forestry options were trading prior to the CFI and so will start early. Other 'low hanging fruit' includes manure management/landfill waste. The others will come on stream as they have "Methodologies" approved. Farmers and land-holders have three options:

ONE: Running a project of their own, gaining the approvals and reporting on their progress.

TWO: Hiring a specialist to manage the reporting and administration.

THREE: Allow an offset aggregator to include their activity with others for trading.

Example: Farmer A chooses to undertake a project to reduce fertiliser use on the farm. Finds the relevant CFI methodology, applies to the CFI Scheme Administrator to become a recognised offsets provider and has their project approved. The farmer reduces fertiliser use (by precision application or biofertiliser substitution or other method). Each year the farmer completes a report, has it audited, then submits it to the Administrator.

Credits are issued into the farmer's account in the Offsets Registry. These are then able to be sold via a broker. The farmer can appoint an agent to handle all the adminstration. Or they can join other farmers as part of an 'aggregation' or pool.

"We are able to breathe, drink, and eat in comfort because millions of organisms and hundreds of processes are operating to maintain a liveable environment, but we tend to take nature's services for granted because we don't pay money for most of them."

~ Eugene Odum

No Get Rich Quick Scheme

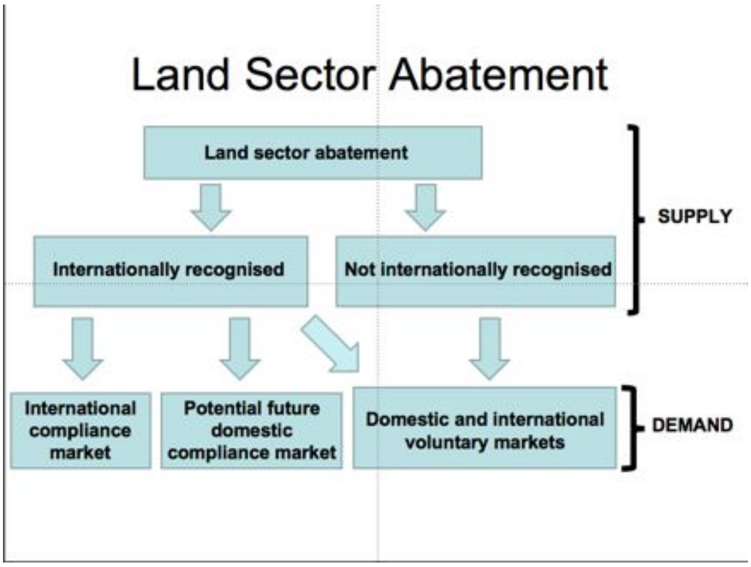
The CFI is not a get-rich quick scheme. Instead it is an incentive program that aims to help land managers make the shift to lower emissions practices. When the CPRS was defeated, Australian consumers and corporates wanting to 'abate' their emissions were offered the voluntary market in the form of the National Carbon Offset Standard (NCOS). It covers all offsets not covered in Australia's Kyoto commitment - which is mainly farm carbon offsets. Forestry is covered by our Kyoto commitment and its promoters were looking forward to the CPRS. Instead they were left without a market. The CFI plugs that gap for forests because it applies to both Kyoto and non-Kyoto offsets. So the CFI and the NCOS fit together.

CFI… NCOS… CPRS… ETS…?

What is the difference between the CFI and NCOS and CPRS and ETS? It's simple: The CPRS (Carbon Pollution Reduction Scheme) was a proposal by the Rudd Government for a "Compliance"-based "Cap & Trade" market for emissions offsets. That is an ETS or Emissions Trading Scheme. "Compliance" means mandatory or 'compulsory'. "Cap & Trade" means emitters must change their business practices to reduce their emissions in order to reach a target level or 'cap'.. If they cannot reach that target in the timeframe given (called a Compliance Period, eg. 2008-2012) they must purchase 'offsets' or 'permits' from emitters who exceeded their targets and earned credits by doing so, or from companies earning credits by generating renewable energy or from companies earning credits by sequestering or capturing and holding CO_2 in forests. Under the Rudd CPRS scheme only 1000 companies were required to meet a target in each compliance period. They were the 1000 top emitters. They could purchase offsets from local or international companies. The NCOS (National Carbon Offset Standard) was designed to operate alongside the CPRS 'compliance' market by providing a "Voluntary" scheme. It allows Australian companies and consumers access to a source of Australian offsets that they can purchase to offset their emissions so that they can make an advertising claim that their products etc. are carbon neutral or simply to make contribution to the climate change effort by offsetting a family's emissions. The NCOS covers only domestic offsets offered to voluntary buyers. The Carbon Farming Initiative completes the set. It covers domestic and international markets, both compliance and voluntary. The only market not covered is the market that is yet to start: the CPRS or the national domestic compliance market.

Who are the buyers?

Demand for CFI credits is expected to come from foreign governments seeking to meet their Kyoto obligations, as well as companies overseas seeking to meet their obligations under national or regional schemes, such as the EU Emission Trading Scheme. CFI credits could also be attractive to companies operating in markets dominated by the voluntary market, such as Australia's traditional trade partner Japan. One important category of buyers not mentioned in the Consultation Paper are consumers overseas who are fans of the country and have a soft spot for Aussie farmers. Back at home, some companies need offsets to meet obligations where State Governments have introduced their own compliance schemes.



Methodologies: Make Your Own

A “Methodology” is a step-by-step plan for helping farmers earn offsets. There is no limit to the number of Methodologies, because the Carbon Market is a free enterprise system. Individuals are free to trade with each other, so long as they don’t break the law. The Government is developing methodologies, with the help of industry. Private project developers can also design their own.

A Methodology has the following parts:

1. A description of the activities that will either avoid emissions or capture greenhouse gasses. The carbon sinks and carbon sources touched Eg. soil, livestock.
2. How the baseline (starting point) and amounts of Greenhouse Gases removed or avoided.
3. How buyers can be reassured that the activities in one location don’t create more emissions some-where else.

4. How the performance of the program will be measured.
5. How the project will be monitored.

The decision to approve a Methodology is taken by the Minister for Climate Change and Energy Efficiency on the advice of the members of the Domestic Offset Integrity Committee - an independent expert panel appointed by the Government.

Integrity Standards

The Carbon Farming Initiative is governed by a set of “Integrity Standards”. They are a list of ‘rules’ that are proposed to give buyers confidence that the abatement offsets they are buying aren’t just smoke and mirrors – that they are real. These rules include:

Additional - the emissions saved or extracted would not have happened without the offset, but are genuinely additional to other efforts.

Permanence – the emissions saved or extracted are not released for the period of the active life of the particular Greenhouse Gasses, eg. CO_2 – 100 years.

Leakage – the project does not create increases in emissions somewhere else that cancels out the initital saving.

Measurable and verifiable – all activity must be accurately measured or estimated; each offset credit must stand for one tonne of CO_2-e; auditing must be independent.

Conservative – estimates and measurement must be conservat-ive to avoid over-claiming.

Internationally consistent – methodologies and reporting practices aligned with those adopted by the United Nations Framework Convention on Climate Change.

Supported by peer-review science – scientific evidence submitted must be ‘peer-reviewed’ which means it has been approved by other scientists in the same field as those doing the research and that it has been accepted for publication in a scientific journal.

The Integrity Standards focus on making the transaction possible by making sure the consumer is confident that they are getting what they paid for. No confidence, no market, no abatement, no sequest-ration of CO2. The logic is undeniable. But it is only as simple as that when you focus only on the transaction.

Turn the telescope around and you see a world that needs as many farmers as possible sequestering as much carbon as possible in their soils and vegetation as quickly as possible. The reason? Because there is little chance that global warming can be held to a increase of less than 2°C without it. Some of the world's leading scientists are saying that the rate at which clean energy infrastructure can be built compared to the rate at which global demand for energy will grow make it now impossible to meet the 2°C target without a big soil carbon component.

Scientists, including the world's most famous Climate Change scientist, NASA's James Hansen, agree that renewables will not be ready to supply the world's energy demands for up to 50 years, if then. In Smart Solutions to Climate Change, Chris Green of McGill University and Isabel Galiana look at current rates of progress and conclude that by 2050 alternative energy sources will produce less than half the power needed to stabilise carbon emissions. By 2100, the gap would be even wider.

Some prominent Australian scientists point to soil carbon as the solution: "It will be next to impossible for Australia to achieve the scale of [emissions] reductions required in sufficient time to avoid dangerous climate change unless we also remove carbon from the atmosphere and store it in vegetation and soils," the Wentworth Group of Concerned Scientists told the recent Victorian Inquiry into Soil Carbon. Even the CSIRO agrees Dr Michael Battaglia, Theme Leader, Sustainable Agriculture Flagship, CSIRO told the inquiry: "What [soil carbon sequestration] actually gives us is time to make those adjustments [transition from burning coal]."

Emissions reductions won't slow down the process of climate change because it is not tomorrow's emissions that are causing the problem, they are your Grandfather's emissions - the carbon released into the atmosphere 70 years ago - that are causing Global Warming. Luckily, we have the only process for extracting billions of tonnes of CO2 every year for 50 years, fully deployed and scaled up, ready to start: Photo-synthesis, in the form of 5.5bn hectares of farmland around the

globe. Scientists such as soil carbon authority Professor Rattan Lal estimate the process can remove 3billion tonnes of CO_2 annually for 50 years. He testified before the US Senate that soil carbon can be a *"bridge to the future" that "buys us time".*

James Hansen and Rattan Lal agree that the world's farmers can draw down the CO_2 equivalent of 50ppm and hold it for 50 years. With the globe racing towards 400ppm, hoping to stop it at 450ppm (to hold the increase to 2°C), soil sequestration is attractive and available and relatively cheap. It would forestall the need for deeper, faster cuts in the future and it would protect the economy from damage. So why is it not activated immediately? Because we are looking down the wrong end of the telescope.

"Too many people either don't know or have forgotten why it is urgent that as many farmers as possible sequester as much atmospheric carbon as possible as soon as possible: both theoretically and practically, there is no other way we can prevent global mean temperatures rising more than 2°C into climate chaos."

A World First for Australia

Australia is the first country to legislate a national carbon offset scheme for farming. The Province of Alberta in Canada has a Provincial Government scheme which started in 2007 and which set the bar so high for farmers to meet its protocols and set the price so low that few have taken it up. The now-discontinued Chicago Climate Exchange was a private enterprise scheme which set the bar too low to attract buyers and could not survive the Global Financial Crisis and the Republicans winning control of Congress. The World Bank has financed the first project that sells soil carbon credits in Africa: the Kenya Agricultural Carbon Project. But no other national government has attempted the complex and politically dangerous task of establishing an incentive scheme which seeks to balance the interests of those in the farm and forestry industries with society's need for food and environmental security.

The Carbon Farming Initiative first saw the light of day as an election commitment made by the Prime Minister Julia Gillard. It built upon the work done by Tony Burke, MP, Minister for Agriculture, Forestry and Fisheries and former PM Kevin Rudd who made it a priority after visiting a carbon farm. Prior to this, Malcolm Turnbull MP threw his support behind it, as Leader of the Opposition, as did Shadow Minister for the Environment, Greg Hunt. The Independent MPs Tony Windsor and Rob Oakeshott provided leverage for our position during the long consultation process before the Carbon Credits (Carbon Farming Initiative) Bill 2011 became an Act of Parliamen

Carbon Farming Initiative 101: The Basics

The following is to be taken as general information only and not relied upon as advice for anyone's particular circumstances. It is recommended that readers seek professional advice before making decisions in this area.

The first and most important 'fact' about the Carbon Farming Initiative (CFI) that you should know is that it is voluntary. No farmer is compelled to take part. It can be easy to confuse the so-called "Carbon Tax" with the CFI. Agriculture is not directly involved in the Government's program to put a price on carbon emitted by Australia's top 500 emitters. Farmers will be indirectly impacted by this scheme when the carbon price starts on 1 July, 2012. Prices of energy and construction materials (steel) could be expected to rise. Fuel (diesel) will not be directly affected until 2014. Food processors are expected to pass on costs.

However, the impact is likely to be less than was predicted by the Australian Farm Institute and the National Farmers' Federation in their vigorous campaign against the "Carbon Tax". The NFF routinely chose to highlight the worst case scenario in the Institute's modelling. The modelling itself – by focusing on the cost side of the equation and ignoring the revenue side – inevitably showed that farmers would suffer losses. The Australian Farm Institute's report on the impact of the "Carbon Tax" is factually accurate and misleading at the same time. It is factual but omits some facts which change the facts. An average grain grower's profits will be slugged $36,000 in extra costs with carbon at $36/tonne. The National Farmers Federation commissioned the research to use in its negotiations with the Government. As an exercise in political theatre, it succeeded. As a basis on which to make decisions, it fails. While the cost curve stretches uninterrupted into the future, it is a false future. It is a future without measures for protecting trade-exposed businesses like agriculture. It is a future without rising food prices as increasing demand due to population rises and shrinking supply due to Climate Change collide and force price takers to take higher prices. It is a future with no farm-based carbon credits generating revenue. And it is a future in which farmers ignore price signals and make no attempt to innovate their way around higher input prices.

The Report doesn't conceal the fact that it is concealing the facts: "The modelling does not incorporate any assumptions about additional dynamic responses (over and above normal productivity growth) by farm business managers to the additional costs, and as such provides a projection of the potential challenge these policies will pose for farm businesses, rather than attempting to predict future outcomes." This distinction between projections and predictions was too subtle and projections became predictions at the hands of the journalists. "Carbon Tax to cripple agriculture" roared the headlines.

Recent CSIRO modelling reveals that the impact on the economy will be milder than the GST's introduction. The real impact will not be known until it arrives.

How to earn Australian carbon credit units

The CFI legislation launches the Australian carbon credit unit (ACCU) which can be earned by farmers and landholders by changing the way they manage the land to create offsets projects. They either reduce or avoid greenhouse gas emissions or sequester atmospheric greenhouse gases in forests or soil.

To protect the interests of buyers and the reputation of the scheme, it is governed by a strict set of rules. Offsets projects must follow an approved methodology which sets out how the outcomes will be measured and managed to meet the Integrity Standards. For instance, the project must result in a reduction in atmospheric greenhouse gas that is additional to what would have occurred if the project had not happened.

One device for assessing Additionality is called the Common Practice Test which acknowledges that farmers change their land management practices as a result of observing the success of others. Activities that are practiced by less than 5% of farmers within an industry or region are not common practice and therefore Additional. (This percentage can increase as a result of farmers taking up an activity in response to the CFI without affecting its 'common practice' status).

Another device for assessing Additionality is a set of two lists: the Positive and the Negative lists. The 'Positive list' of activities are said to be additional and the 'Negative list' of activities, which are said to have bad environmental or social impacts, are not eligible offsets projects.

The Positive List: What You Can Do

The following activities are deemed additional under the Carbon Farming Initiative:

1. Establishment of permanent environmental plantings: after 1 July 2007; or under the Greenhouse Friendly initiative, planting species native to the local area, including a mix of trees and understorey species. It cannot be harvested but may undergo thinning.
2. Establishment of permanent mallee plantings after 1 July 2007.
3. Regrowth - Re-establishment of native vegetation on private land from residual seed sources through the exclusion of stock, the management of the timing and extent of grazing, the management of feral animals, the management of weeds or cessation of mechanical or chemical destruct-ion.
4. Restoration of drained wetlands on private land.
5. Application of biochar to soil.
6. Capture and combustion of methane from waste deposited in a landfill facility before 1 July 2012.
7. Capture and combustion of methane from livestock manure.

8. Early dry season burning of savanna areas greater than 1 km^2.
9. Management of feral camels on private land.
10. Using tannins as a feed supplement for ruminants.

- The use of tannins as a feed stock is expensive, does not improve productivity and is still at the development stage.
- A number of technologies are under development to reduce methane emitted by ruminants.

11. Incorporating *Eremophila (Emu Bush)* into feed for ruminant livestock.
12. Manipulation of gut flora in ruminant livestock.
13. Application of urea inhibitors to manure. To reduce nitrification in manure into management practices. This abatement practice is at the development stage.
14. Application of urea inhibitors to fertiliser.
15. Diversion of putrescible waste from a landfill facility to an alternative waste treatment facility before 1 July 2012.

The Negative List: What You Can't Do

The following are ineligible projects under the CFI:

1. Projects that were mandatory at 24 March 2011.
2. Establishment of vegetation on land subject to clearing of native forest or draining of a wetland within 3 years of application as an eligible offsets project.
3. Planting a known weed species.
4. Establishment of a forest as part of a forestry managed investment scheme.
5. Cessation or avoidance of harvest of a plantation forest.
6. Planting trees in an area that receives more than 600mm long-term average annual rainfall, except when:

- it is a permanent environmental planting;
- it is for management of dryland salinity;
- there is a high security water access entitlement for the life of the project;
- there are no adverse impacts for other water users and environmental flows.

Permanence: What You Must Do

A sequestration project must be permanent so that offsets buyers can be confident that the unit represents the same genuine abatement of a unit based on avoided emissions. To be permanent, it must be maintained "on a net basis" for around 100 years. The landholder must maintain the carbon in soil that has been 'traded' as offsets, or restore it if lost. Offsets must be 'relinquished' or handed back only if it is not restored. A carbon maintenance obligation 'runs with the land' and will therefore apply to future land owners.

It is possible for emissions to increase as the result of carrying out a project. These must be deducted from abatement estimates. Increases in emissions can be the direct result of the project and within the control of the project proponent. Eg., increasing nitrogen fertilizer application can increase carbon

NRM Plans

To avoid 'perverse outcomes' (negative outcomes arriving along with positive outcomes), projects must gain approval under any relevant natural resource management (NRM) plans, if they exist. (This introduces another

All sequestration projects have a small percentage of ACCUs deducted from the total to insure against temporary carbon losses after "certain natural or human-induced events". The 5%.risk of reversal buffer is designed to insure the scheme against temporary losses of carbon whilst carbon stores are recovering, and losses as a result of wrong doing by the project proponent that cannot be remedied, for example if the project proponent leaves the country.

Leakage

sequestration in soils, but there could be increased emissions of nitrous oxide. Increases in emissions can also occur as an indirect result of the project. Eg., de-stocking one property is likely to lead to increases in stock numbers on other properties if demand for beef stays firm.

level of bureaucracy and delay in an already highly-regulated system.)

Fit and Proper

A person must be an accredited 'recognised offsets entity' to receive ACCUs, that is, they must satisfy the 'fit and proper person' test. For example, people who have been convicted of an offence relating to the conduct of a business or dishonest conduct will be excluded.

No licence needed

The ACCU is classified as a financial instrument. This means that anyone wishing to carry on a business selling ACCUs or giving advice about ACCUs must hold an Australian financial services licence (AFSL). However farmers and landholders selling their ACCUs on their own behalf are free to do so without needing an AFSL.

'Recognised' project

A project must be an accredited 'recognised offset project' to be registered as a source of AAUs. Such a project meets the following guidelines:

- Project is conducted in Australia
- Has an approved methodology
- Passes the Additionality test
- If a sequestration project on Crown land or Commonwealth property, applicant must hold carbon sequestration right. (Only WA and Qld legislated carbon rights for lessees.)
- Project does not involve clearing native forest or using material obtained from clearing or harvesting native forest
- Operation presents no real risk of adverse impact on: water availability, biodiversity conservation, employment, or the local community.
- Has consent of all relevant interest holders in the land.

Methodology

Farmers and landholders wishing to earn and sell offsets must use an approved methodology which sets down how the offsets are to be created. This includes how the offsets are to be measured and verified, how the offsets are Additional, how the sequestration can be Permanent, and how Leakage can be estimated.

Approved methodologies can be found on this web site (www.climatechange.gov.au/cfi)

Where no methodology exists, farmers and landholders can propose one and submit it for approval. Methodology approval is dependent on the independent expert committee (the Domestic Offsets Integrity Committee). The public have 40 days to comment on the proposed methodology which is published on the DCCEE website.

ACCUs

Two types of ACCUs will be created: Kyoto-ACCUs and non-

Kyoto ACCUs. An offsets project is called "Kyoto" if it is recognized under the international accounting rules established as part of the Kyoto agreement. A Kyoto ACCU can meet Australia's commitments under the Kyoto rules. The holder of Kyoto-ACCUs can apply to have them exchanged for Kyoto units. Kyoto units can be traded amongst those Kyoto countries that have agreed to binding targets.

ACCUs and Biosequestration

Land management practices that enhance sequestration and are covered by the CFI include:

- Reforestation
- Revegetation
- Native forest protection
- Avoided de-vegetation
- Improved management of forests
- Reduced forest degradation
- Forest restoration
- Rangeland restoration
- Improved vegetation mgmnt
- Enhanced or managed regrowth
- Enhanced soil carbon

While biosequestration from a wide range of activities could be credited, not all will be internationally recognized at the outset. For example, improved forest management, revegetation and activities that increase carbon in agricultural soils are not recognised under the current international framework and would receive non-Kyoto ACCUs. Biosequestration is an evolving area of interest as the international arrangements to replace the Kyoto agreement are negotiated.

Native forest protection projects

Projects that involve the clearing of native forests or using material obtained from the clearing or harvesting of native forests are excluded. Clearing of low-density native forest to establish a higher-density carbon sink plantation, or biochar projects that source materials from native forests are therefore excluded.

Emissions avoidance

The CFI covers reductions in emissions from savanna burning and agricultural production (livestock/methane and fertiliser use/nitrous oxide).

These emissions are recognised under the Kyoto Protocol. The CFI covers reductions in emissions from feral animals that are not managed within an agricultural system (camels).These are not recognized internationally.

A Soil Carbon Methodology

A methodology for generating offsets from activities that produce sustainable increases in soil carbon has been submitted to the Domestic Offsets Integrity Committee (DOIC).

Submitted by The Bridge Consortium (Carbon Farmers of Australia, Object Consulting, and Offset Generation Services), the methodology innovates around the 'wicked problems' of Measurement, Additionality and Permanence.

Addressing Measurement: The offsets buyer must be confident that they are getting what they are paying for. When they buy a tonne of CO2 either avoided or captured and stored. The ability to measure soil carbon accurately is a key concern. While there are several technology solutions in the satellite remote sensing and on-the-fly ground sensing yet to be made commercially available, the choice is between Models vs Direct Measurement. The Bridge Methodology uses Direct Measurement for the following reasons:

Science lags the innovators: the models rely on peer review data on the rate of increase in soil carbon that can be achieved by using a particular land management technique in a particular climate zone. The process of producing peer review data relies on three-year trials plus the time it takes to have the results reviewed by fellow scientists and then the publication of the results in a suitable academic journal. Depending on the availability of research funds, it can take up to five years for a single cycle of the peer review.

To fully populate the models will take more than two cycles. Science will always be between 3 and 10 years behind leading edge innovators. Models don't cover new techniques.

Models don't cover combinations of techniques which are closer to on-farm reality and likely to increase soil carbon levels much faster than the single technique approach.

For this reason, returns to farmers from the current model-based system – when it comes available – would be far too low to attract any supply for the market.

For these reasons, we need to use direct measurement in short term. Under the Bridge methodology, the measurement challenge is answered by reducing the uncertainty around direct sampling, using a 1:1 buffer mechanism that delivers a 95% confidence interval. This means the farmer wanting to sell one offset unit must 'bank' another unit as insurance that the buyer can be sure that they got what they paid for.

This approach is simply extending the Government's own 5% 'risk of reversal' buffer into a Project Buffer. The participant 'banks' a tonne of CO_2 for each tonne they trade during the first 5-year period. From the second 5-year period onwards all growers are placed in mutual insurance Program Buffer Pool that aggregates risk management and balances impacts across a range of climate zones. This reduces the grower's exposure while increasing buyer protection.

It allows the added security of a balanced pool of projects rather than relying on a single farmer or piece of land only. This means that in subsequent periods abatement is determined across an aggregated project group using a weighted mean approach by pooling of land parcels within a given vintage, underwritten by buffers pooled across all vintages.

The buffer contribution is reduced to 10% in the 3rd 5-year reporting period.

Addressing Permanence The 100 Year Rule can be resolved entirely should the Program Buffer Manager accept a relinquishment responsibility entirely on behalf of a grower. There is a precedent for this: US-based Finite Carbon's Carbon Reduction Corporation offers complete coverage for all reversal risks including so-called intentional reversals to any forest carbon project, with project developers paying for this coverage with credits from their project or with cash. The risk mitigation product holds a 1:1 reserve for all insured tons.

Addressing Additionality: The Bridge Methodology for Soil Carbon overcomes the Common Practice Test (ie. activities that are not common practice within an industry or region – eg. practiced by less than 5% - are deemed Additional) by means of the '3+2" Solution:

Participants are required to implement combinations of practices.

All must adopt 3 required practices: minimum tillage, reduced inorganic fertiliser, and project monitoring. On top of that, participants must choose at least two additional practices/ products drawn from a menu of approved products and processes.

The statistical likelihood of enough participants would choose the same combinations of practices to breach the 5% limit is low.

Carbon Tax Funds Farmers

The land sector benefits from the Carbon Tax to the tune of $1.7 billion over 6 years, including $250 million for the Carbon Farming Initiative non-Kyoto Carbon Fund. This will be used by the Government to purchase carbon credits that will create "incentives to undertake land-based action such as the storing of soil carbon, revegetation and forest conservation." The Government's $40 million per year can purchase 4 million units at $10 (price not indicated). (The Opposition's Direct Action soil carbon plan to purchase 10 million units in 2012-3, rising to 85 million units per year in 2020.)

A further $201 million has been earmarked for research into "new ways of storing carbon and reducing pollution in the land sectors." $20 million will be available to "convert research into practical methodologies which are recognised under the Carbon Farming Initiative." Up to $99 million will be provided "for landholders to take action on the ground, including testing new ways to increase soil carbon and reduce pollution." [Farmer research]

There is $900m in a Biodiversity Fund "for landholders to undertake projects that establish, restore, protect or manage biodiverse carbon stores." This will include:

• reforestation and revegetation in areas of high conservation value including wildlife corridors, rivers, streams and wetlands

• management of biodiverse ecosystems, publicly owned native forests and land under conservation covenants or subject to land clearing restrictions

• preventing the spread of invasive species across connected landscapes.

Finally, $44 million will provide "a refundable tax offset to encourage the uptake of conservation tillage farming techniques and participation in soil carbon sequestration research". This will cover 15% of the cost of equipment and the program runs for 3 years.

Carbon Offsets Value Proposition

Avoided Emissions	Soil Carbon Sequestration
1 tonne CO2 not emitted today	Approx. 1 tonne CO2 removed†
	Improved Soil Health
	Reduced Erosion and Soil Loss
	Improved Water Efficiency
	Increased Biodiversity
	Buffer Against Drought
	Increased Production
	Increased Farm Family Incomes
	Food Security
	Secure Bridge To The Future

Fig. 1: It is often stated that only offsets grounded in robust science would command consumer confidence and healthy prices. Soil Carbon Sequestration does not have the support of ‘peer-reviewed science’ at present, due to a lack of interest among scientists until recently. However considerable support has been voiced for the benefits listed here by the most senior and respected soil carbon and climate scientists. Let the market decide.

*No guarantee that it will not be mined and burned in future.
†No guarantee to hold it for 100 years.

"How much can I make from soil carbon?"

Farmers have been asking me that question for 6 years. I could never give an answer… until now! These are conservative figures, too. In the worst drought in living memory, serious carbon farmers grazing sheep or cattle on the Slopes of NSW were able to increase carbon levels in their soils by between 2.5% and 3.5% over 10 years. They did it by using combinations of land management practices, eg. grazing management, pasture cropping and biofertilisers.

We now have a fair idea of what the price for sequestered carbon is likely to be on both the Carbon Farming Initiative (CFI) and the Opposition's Direct Action program: around $12/tonne on the voluntary market. For the sake of being conservative, we'll reduce the increase to 2% and we will measure the top 30cm soil profile, as required by the CFI. We'll set Bulk Density at 1.2.

A 2% increase in these circumstances would result in 264 tonnes CO2-e/ha in 10 years, or 26.4 tonnesCO2-e/ha/year.

At $12/tonne, you have $316/ha. Over 250ha, you could gross $79,000 per year.

Subtract 10% for aggregation and brokerage costs, and you have $71,100

Subtract 50% for the first 5 years (for Permanence and Measurement insurance, which falls to 10% in the 3rd 5 year period). Your cost of inputs should fall, with a switch from inorganic fertiliser.

So for the first 5 year reporting period you might net $35,550/year.

Assuming the insurance falls to 20% in the 2nd 5 year reporting period, the net income could approximate $56,880/year. In the 3rd and 4th 5-year reporting periods you could net $63,990/year.

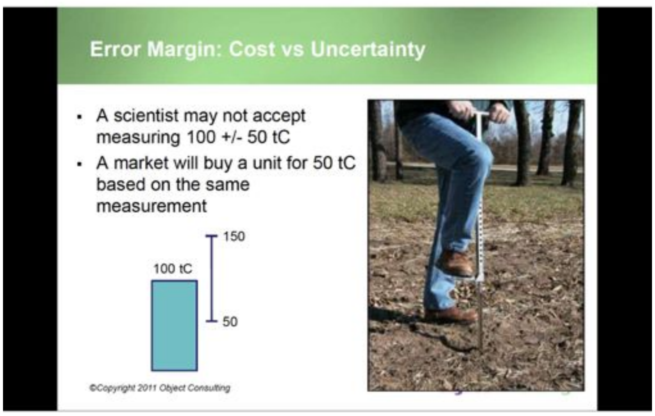
That is an average net income of $55,102/year over 20 years.

This is just a start. You could enrol more than the 250ha on which these figures are based. The price could move upwards before your first reporting period ends. Your units could become eligible for the higher prices expected in the compliance market.

But this is only one 'enterprise' in your Carbon Farming Portfolio. You would continue to produce food and fibre. Meanwhile you could be earning income streams from strategic tree plantings, feed supplements and rumen inoculants and breeding programs to suppress methane emissions, and fertiliser reductions.

We don't know enough about likely returns from these activities to be able to predict what a dedicated, optimised Carbon Farm could generate from them. And this is before we see what the $2bn farm landscape restoration fund will mean for farmers.

"Potential" returns from soil carbon sequestration – under the conditions of this methodology – are based on the experience of farmers who perform to their potential.



Potential returns from soil carbon sequestration in a grazing enterprise *(Indicative figures only. Individual cases will vary with location, soil, climate, management.)*		
Basic data: Grazing properties Central NSW Slopes 2%C increase over 10 years[48] Area: 250ha Bulk Density 1.2	10cm core sample	30cm core sample
Annual increase CO2-e:	8 tonnes/ha/yr	26.4 tonnes/ha/yr
Gross return per hectare @ $12/tonne	$96/ha/yr	$316/ha/yr
Gross return on 250ha	$24,000/yr	$79,000/yr
Less 10% Aggregation & Brokerage[49]	$21,600/yr	$71,100/yr
Less Measurement/Permanence "Insurance" (Buffer Pool)[50] 1st 5yr period[51] (50%) 2nd 5yr period (20%) 3rd 5yr period (10%) 4th 5yr period (10%)	 $10,800/yr $17,280/yr $19,440/yr $19,440/yr	 $35,550/yr $56,880/yr $63,990/yr $63,990/yr
Average Net Income over 20 years	$16,740/yr	S$55,102/yr

[48] This rate of sequestration is based on the experience of skilled Carbon Farmers using combinations of land management practices that have not been subject to trials by scientific bodies.
[49] This rate is an estimation based on North American cases, eg. Alberta Climate Exchange, Chicago Climate Exchange.
[50] The Buffer Pool concept – as proposed in a methodology submitted by the Bridge Consortium - establishes a 90% Confidence Interval to manage uncertainty surrounding the CFI Integrity Standards Measurement and Permanence.
[51] The Bridge Methodology features four 5-year reporting periods.

Potential of Australian Soils to Sequester Carbon

• Dr Peter Fisher indicated that standard soil carbon models may need to be adjusted when he reported his results in a press release from the NSW DPI on 24 December, 2008. "Most carbon modelling indicates that increasing soil carbon is a very slow process, taking many decades to achieve significant changes. For example, modelling a 2 t/ha increase in organic matter input for the same conditions, results in a change in soil carbon value of about 0.13% after 20 years… In contrast, the relationship developed between change in organic matter input and change in soil carbon at the 13 paired paddocks in the trial, suggested that a 2 t/ha increase in soil organic matter might result in approximately a 0.4% change in carbon level, after only 10 years." "This increase is greater than most carbon modelling suggests," Dr Fisher said.

• Tim Wiley, WA Department Agriculture & Food, reported that farmers in the South West were recording between 5t and 10t CO2e increases annually when they introduced perennial pastures and pasture cropping to the sandy soils there. This has been compared to sequestration of less than 1.5 tonnes CO2-eq/ha/yr by annual systems. (SENATE STANDING COMMITTEE ON RURAL AND REGIONAL AFFAIRS AND TRANSPORT, Senate, Final Report, December 2008). Tim spoke at the 2008 Carbon Farming Conference.

• Colin Seis, Gulgong NSW saw his soil carbon rise from 1.8%C to 4%C in 10 years, or 0.2%/yr while he was developing Pasture Cropping, direct drilling a cereal crop into dormant perennial pasture. He believes he could halve the time given what he knows today.

• Anne and Ray Williams of Magomadine near Coonamble were named the 2007 Carbon Cockies of the Plains, held as part of the Carbon Farming Expo & Conference. Anne won a grant from the GRDC to study soil treatments and carbon. In the case in hand, they recorded a 1.2%C/yr difference between 'no-till' and 'no-till and compost tea"

• Microsoils and VRM (Prime Carbon) report a case where soil carbon rose 2%C/ha between 12/2/07 and 25/04/07. This was on a Canberra pasture operation. The soil was inoculated with benign micro-organisms after they had spent a long period together in a nutrient rich bath (to avoid shock when distributed).

Frequently Asked Questions:

Q. Do I have to take paddocks out of production to grow soil carbon?

A. No. This is a misunderstanding some people have. The best way to grow soil carbon is to actively use the soil to grow vegetation, either crops or pasture. Vigorous plant growth means vigorous root growth which stimulates a feeding frenzy and other carbon-growing activities among the microbial communities that live in your soils.

Q. Do I have to buy additional Nitrogen, Phosphorous, and Sulphur to grow Humus?

A. There should be sufficient quantities of these elements already fixed in your soil, the result of over-fertilization in the past or through the natural microbial processes that can capture Nitrogen from the atmosphere or find P 'fixed' in soil. The simple act of growing soil carbon unlocks these processes.

Q. Is it true that Australia's soils are too old and weathered and degraded to sequester much carbon?

A. This is an old wives tale left over from older, more ignorant times. Two of our most eminent soil scientists dismiss this old story: Dr Yin Chan from the NSW DPI says that we have lost 75% of the soil carbon in our soils and we can get it all back again. Professor Alex McBratney from the University of Sydney says age has nothing to do with soil's ability to absorb carbon. In fact, our soils have more capacity to absorb carbon due to their age and state of disrepair.

Q. Many speakers tell us that we will have to pay large amounts of money for our animals methane gases and that we can't rely on soil carbon to help us pay for it. Is this true?

A. Minister for Agriculture Tony Burke announced on March 3, 2010 that farmers will not be penalised for the methane emissions and nitrous oxide emissions from their operations. This is not law yet, but is part of the Government's offer to the Opposition on the Bill. Naturally, if you want to do something to address the emissions, there are many ways you can reduce your methane, for instance: Introducing rotational grazing to provide your stock with as much fresh feed as possible lowers their emissions. Or simple things like adding Flaxseed Oil can reduce methane emissions from cows by up to 40%. (For soil carbon potential.) On balance, you should be able to reduce for your emissions by changing your land management and your stock management to reduce.

Q. How much carbon can I grow in my soil?

A. That depends… on some 'fixed' things and some 'variable' things. The fixed things (ie. those you can't control) include rainfall (the more you get the better, up to a point), soil types (cracking, self-mulching clays are best; sandy soils are less effective; but everyone can grow something), land management history (if it has been over-grazed or ploughed up ever year since 1788, etc. you are looking at low hanging fruit; the only better prospect island which has been managed for regeneraton for several years and is coming into a period when a carbon growth spurt is possible), and climate (is it getting drier or wetter, hotter or colder? Wetter and colder is best. So most of us are facing the opposite.) The "variable" things are: your choice of land management ("Carbon Farming" aims to leverage the immense power in the biological community beneath the surface, so it offers land managers a complete portfolio of techniques – grazing management, pasture cropping, perennial cover cropping, composting, compost teas, mulching, probiotic amendments, organic and biological farming, etc.; all of them aim to encourage humus-making processes conducted by fungi called "mycorrhizal" which flourish under perennial grasses rather than annuals; microbial communities don't like direct sun or temperatures too high, so we aim to keep the ground covered at all times, etc.) But any technique that works for you is fine. There are no rules. Every property is unique. The fastest rate of growth we have witnessed is a 2% increase in 2 months on a grazing property near Canberra that was treated with a probiotic microbial brew. The slowest rate of growth recorded by a Carbon Farmer that we know of is 2.2% in 10 years.

Q. This soil carbon doesn't sound very stable. How can we keep it once we sequester it, especially the "labile fract-ions"?

A. Those who speak about the fractions of carbon give the impression that carbon is impossible to hold. But while scientists are interested in measuring fractions, buyers don't care. They want a tonne or 200 or 2000 or 20,000 tones of CO2-e. So sellers are only interested in Total Carbon, specifically the "delta" or change in TotalC between Time A and Time B. So how do we handle the notorious 'flux'? We don't. The buyer does not want a particular molecule of

CO2-e to be captured and held. They want to know that the 'value' of that molecule is held, plus one. The molecule can oxidise without breaching your contract because the Carbon Farming System is maintaining and increasing the level in the leaky bucket. The labile fraction is not the focus of the Carbon Farmer's efforts; by encouraging the symbiotic fungi, such as arbuscular mycorrhiza and vesicular arbuscular mycorrhiza, we skew the dominant activity towards humification, ie. the process of making stablised, easily retained. These fungi get their food as a liquid from the roots of plants in return for elements that the fungus's long fingers (or hyphae) search out in the surrounding soil. Other fungi – the decomposers – are more at home in conventional farms and feed on decaying organic matter, such a retained stubble - in a way that causes carbon to be released. They are not important in carbon storage. Storage is an area of risk that cannot be managed by science. It can only be managed by a market mechanism: price.

Q. How much can I earn growing soil carbon?

A. That depends… on which market you sell into (domestic or international, mandatory or voluntary, commodity or 'branded'/'gourmet' market); it depends on when you are selling (whether there is a glut or a shortage, as with any market); you are advised to watch the market; your aggregator will advise you. Don't forget: you are taking on an important responsibility that will last longer than the money. You are committing – under contract – to keep that carbon level within the bounds of the agreement, for the period agreed.

Q. How do I sell the carbon I grow?

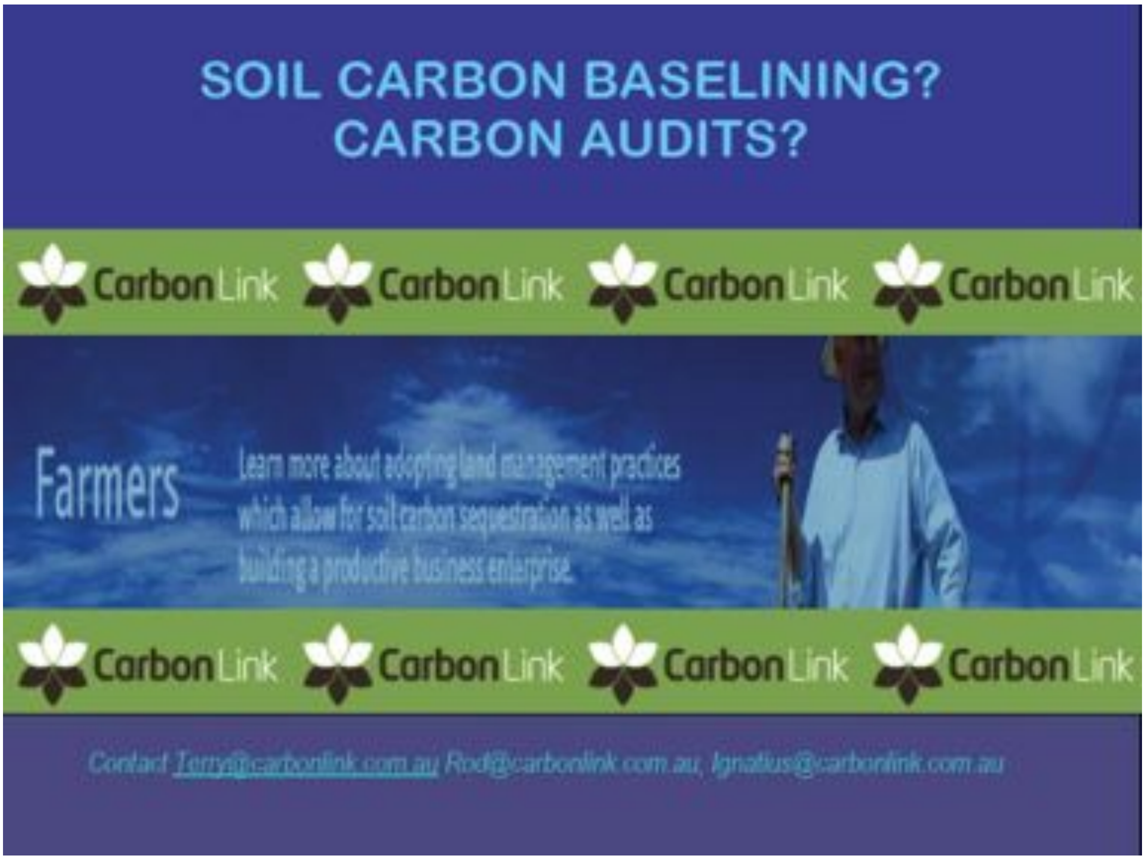
A. There will be three types of middlemen helping you to find a buyer: 1. Aggregator – buyers in the commodity market buy in lots of 25,000tonnes of CO2e or more. This is more than the average grower can manage alone. So an aggregator gathers together parcels to make up marketable lots and presents them to a broker. 2. Broker - undertakes to find a buyer at the best possible price. 3. Pool Manager – A Pool System is a risk management system for the grower. A percentage of the tonnes the grower submits is held aside as a "Buffer Pool" in case of a reversal in carbon through fire, drought, or misdventure. It is submitted for sale as the maturity date approaches and the risk has reduced.

Q. How much will these middlemen take?

A. The “middlemen” or market services sector operates like any market, the price reflecting costs and demand and personal reputation, among other attributes. In the early stages of the Chicago Climate Exchange, the first soil carbon market, the total commission on a sale was 30% on very small volumes, but this fell to 10% as volumes grew.

Q. Why do I read and hear so much criticism of the trade in soil carbon?

A. Soil Carbon trading is totally new. Climate Change is totally new to most people. Many people find anything NEW disturbing, especially when it threatens to interfere with their established patterns of life. Many in soil science, nobly, believe it is their responsibility to reveal the truth about claims made about soil carbon by newcomers. However it turns out that the scientists are working from old, out-of-date data. None of the models which power the calculators is populated with data from studies of Carbon Farming techniques. So the advice Governments and farmers have been getting about the potential of soils is based on “out-dated science.”



Australian Farm Offsets: Building the Brand

It is not inevitable that Ausralian Farm Carbon Offsets will sell at low prices because they will be confined to the Voluntary Market. People buy brands. Brands have meaning and a story to tell. The following are the building blocks of our brand.

Buying emotions: In a 2009 survey conducted by EcoSecurities, Conservation International, CCBA and ClimateBiz, of the 120 corporates surveyed more than 77% rated community and environmental benefits as the prime motivator for purchasing carbon offsets.

A paper from the Overseas Development Institute offers some indicators to be used in assessing the potential developmental impacts of voluntary carbon offset schemes:

- What potential does the project have for income generation?
- What effects might a project have on future changes in land use and could conflicts arise from this?
- Can small-scale producers engage in the scheme?
- What are the 'add on' benefits to the country - for example, will it assist capacity-building in local institutions?

Australia's farmers not climate trogs: Nearly 66% of farmers in Australia believe Climate Change has affected the weather in their location. 50% have changed their management practices as a result. These are the latest figures from the Australian Bureau of Statistics – the survey was conducted in 2006-2007. Victoria has the most 'climate smart' farmers (58% say they have changed management practices) followed by SA and TAS (50%), NSW (47%), WA (41%) and NT (15%).

Farmer's vital statistics: Farmers occupy and manage 61% of Australia's landmass, as such, they are at the frontline in delivering environmental outcomes on behalf of the broader community. *(Australian Government Department of Agriculture, Fisheries and Forestry, At a Glance, 2010.)*

Australian farmers spent $3 billion on Natural Resource Management (NRM) over 2006-07, managing or preventing weed, pest, land and soil, native vegetation or water-related issues on their properties. More than $2.3 billion was spent on weed and pest Management, while land and soil-related activities accounted for $649 million of total expenditure. *(Australian Bureau of Statistics, Natural Resource Management on Australian Farms 2006-07.)*

94.3% of Australian farms actively undertake Natural Resource Management. *(Australian Bureau of Statistics, Natural Resource Management on Australian Farms 2006-07.)*

52% of farmers undertake activities to protect native vegetation, 45% wetland protection and 49% river or creek bank protection. *(Australian Bureau of Statistics, Year Book Australia, 2009-10.)*

Farmers improving their Natural Resource Management practices reported doing so to increase productivity (88.6%), farm sustainability (88.4%) and better environmental protection (74.5%). *(Australian Bureau of Statistics, Natural Resource Management on Australian Farms 2006-07.)*
9.2 million hectares has been set aside specifically for conservation/protection purposes by farmers. *(Australian Bureau of Statistics, Year Book Australia 2009-10.)*

Speed of soil loss: Soil scientists estimate some 75 billion tonnes of soil are lost annually with more than 80 per cent of the world's farming land "moderately or severely eroded". A University of Sydney study - released in 2009 at the Carbon Farming Conference - found soil is being lost in China 57 times faster than it can be replaced through natural processes; in Europe the figure is 17 times, in America 10 times while 5 times as much soil is being lost in Australia, but we never had the 'reserves' of topsoil of the other countries. Increased land pressures aimed at compensating global production losses would likely mean it top soil will run out faster. John Crawford (Professor of Sustainable Agriculture at the University of Sydney), said it was 'unknown how long soil will last; it could be as little as 60 years and that is a scary figure because it is not obvious that we have time to reverse decline and still meet future demands for food; it is not an exaggeration to say that soil is the most precious resource we have got, and… (we) are not up to the task of securing it for our children never mind our grand children'.

Eating our future: In Australia's top wheat growing areas 13 tonnes of soil is lost through erosion for every tonne of wheat produced (Lawrence & Vanclay 1992, p. 40). A thirty year study has revealed that 8 tones per hectare of soil is lost in summer cropping of annual cereals - compared with 0.01 tonnes lost from undisturbed native forests (Turner, Wareing, Flinn & Lambert 2004). In the world as a whole soil is being lost to erosion at the rate of 5 tonnes per person per year (Trainer 1995, p.18; see also Watson 1992, p. 21).

- *Lawrence, G. and Vanclay, F. (1992) 'Agricultural Production and Environmental Degradation in the Murray-Darling Basin', in G. Lawrence, F. Vanclay and B. Furze, Agriculture, Environment and Society: contemporary issues for Australians, Macmillan, Melbourne.*
- *Trainer, T. (1995) The Conserver Society: Alternatives for Sustainability, Zed Books, London*
- *Turner, J.,Wareing, K., Flinn, D. & Lambert, M. (2004), Forestry in the Agricultural Landscape, Department of Primary Industries, Melbourne*

On average, 90% of Australia's soil erosion from agriculture comes from 20% of the agricultural land area (National Land and Water Resources Audit, 2002). Up to a third of the total area of rangeland showing acute symptoms of soil degradation, and 50-65% of crop land at risk in any one season from wind erosion. A joint Commonwealth/States collaborative study in 1975–77 determined that more than one-half of the land in Australia used for grazing or the growing of crops needed treatment for land degradation. This area totalled more than 2.6 million square kilometres. A more recent study estimated that by 1983, two-thirds of Australia's farmland needed soil conservation treatment. The Institute of Foresters of Australia estimated that for every dollar dryland salinity cost: water and wind erosion cost $5, soil acidification cost $25, soil structural decline cost $125, and soil nutrient degradation cost $625.

Data indicate that anything under 70% of ground cover affects runoff and soil loss. The percentage of ground cover affects the frequency and the amount of soil loss, and major rainfall accounts for most of the runoff. A stubble cover of 30% is required on cultivated areas to halve erosion rates when compared to the erosion rates from 10% stubble cover obtained after burning.

http://www.environment.nsw.gov.au/soildegradation/gullyerosion.html

§

"What we are after is an ethic of farming,
a philosophy of agriculture,
with particular attention to agriculture's impact
upon and integration with the wider natural world.
"This philosophy is needed as much by those who eat
as by those who farm.
Food consumers see too little of farming
To form an idea of agriculture.
They demand traits and characteristics in their food
that have little relation to its origins and production.
The act of eating is split between the metaphors
of refuelling at the pump, and pleasing the senses
as one might at a concert or museum.
Nearly gone is the spirit of raising food and eating it
as an act of communion with some larger whole."

- Paul B. Thompson, The Spirit of the Soil

§

Where The Wild Things Are

Long before there was Agricultural Science there was Agriculture. Farmers got along without scientists by doing whatever worked for them. They invented the sickle and the plough, simply by following their noses, driven by practical necessity. When they had a problem they couldn't solve for themselves, they consulted the priests who cut open a chicken. The scientists eventually replaced the priests because their magic worked more often. But the endless quest for 'what works' draws farmers away from the straight path of what science says works and into the woods where the wild things are.

Wild things can be dousing for water or detecting energy lines or the use of radionics to measure energy levels in produce are the work of charlatans for the scientist. They have no peer-review to support them. Still the open-minded farmer keeps his antennae tuned for wild things. Who knows, many accepted practices today started life as wild things. Terry McCosker from RCS takes an early look at a wild future..

Terry McCosker RCS

There lies ahead a great frontier that could contain solutions to many of the burning issues of the modern 'agricologist'. How can we reduce or eliminate synthetic fertilisers and toxic herbicides and pesticides that poison soil microbes and reverse the process of carbon sequestration? How can we eliminate these things while increasing yields? There are solutions… in the woods. For instance, a man in India is being observed by scientists because he has an extraordinary gift to make changes to plants and farm animals just by thinking about them. He is not a holy man in a saffron robe. Mahendra Kumar Trivedi is said to change living and non-living matter with what are termed Energy Trans-missions or "bless-ings" (focused intentional cons-ciousness, called The Trivedi Effect™). "Through collab-orations with many researchers in six countries from numerous scientific fields, Trivedi has amassed a broad set of data substantiating this ability in a scientifically demon-strable and measur-able manner," says his website. In Agriculture Trivedi has been able to grow crops with no use of chemical fertilizers or pesticides while providing increased nutritional value (300% increase in bio-photons), increased yields (up to 500%), and increased immunity (up to 300%). Just by 'focused intentional consciousness' on it, he makes it happen.

"Through continued collaboration with the international scientific community, we will broaden our base of understanding of the previously demonstrated effects and create ground-breaking new paradigms of the nature of human consciousness and its relationship to the material universe," says Trivedi. A herd of 350 dairy cows was blessed and experienced a

30% leap in milk production. In 2005, Dr JS Bohra, Department of Agronomy, Institute of Agricultural Science, Banaras Hindu University recorded in a Mustard crop a 61.5% increase in yield and a 365% increase for Chickpea after a Trivedi blessing.

Dr Patrick McMannaway is an Scottish version of M.K.Trivedi. He is a geomancer, 'remediating geopathic stress and balancing and optimizing landscape energies for crops or pastures'. In other words, certain places have good energy and others don't, and he can fix it by thinking about it. He also has an impressive track record, with up to 60% reduction in mastitis, up to 50% reduction in calf mortality, 10% increase in potato yield, and 20% increase in wheat yield. Like Trivedi, Patrick has the attention of scient- ists. At the "Potatoes in Practice 2011" - Britain's premier field-based event dedicated to the potato industry – a subtle energy remedy was sprayed at point of planting on one of the trial plots and included in the Under the Ground Treatments category as a "novel treatment that has shown promising results elsewhere in the country". Subtle Energy Enhance-ment gave this plot a total yield of 54 tonnes/ha, 2 tonnes ahead of its nearest rival and 21 tonnes more than the conventional option..

"Focused Intentional Consciousness" can increase yield. But can it increase Carbon in soil?

Out somewhere on the fringe - where the wild things are - also relying on science to give it credence, is Agrohomeopathy. It means using potentised preparations for the health of plants and soil. In October 2011 the first international conference on Agrohomeopathy took place in in Gloucestershire, UK. Delegates from 13 countries reported on their research Dr Iftikhar Waris Shah of Lahore, Pakistan reported his results over two years with a homeopathic treatment for a mealy bug infestation affect-ing the cotton crop. A homeopathic prepar-ation was tested on various strains of cotton to see if there was any impact on mealy bug infestations. The potentised candidate was equally as successful as the standard neonic-otinoid and a water control. The idea of physical objects being changed by someone merely thinking about them sounds like some-thing out of Star Wars .

"Focused Intentional Consciousness" can increase yield. But can it increase Carbon in soil? Trivedi claims to be able to change the DNA in plants and microbes, and change the genus and species in harmful bacteria. With these skills he could manipulate the genetic structure of soil organic matter to produce higher concentrations of humus. He could also change the production of above and below ground biomass.

It seems inevitable that alternative farming will be awash with powerful options for farmers seeking a deeper connection with the mysterious forces that run unseen and unchecked. Can you increase soil carbon levels simply by using your mind?

Science is innately backward-looking. It fears new ideas like Mercury in the bloodstream. So someone else has to conduct the trial and error. Someone willing to stray from the straight path of what science says works and into the woods where the wild things are.

How To Speak "Carbon"

The Age of Carbon brings with it a new language and a new set of concepts which do not come naturally to the mind. However it is essential that you understand them, if only for self defence. These definitions are taken from various official (IPCC) references, including the IPCC Good Practice Guidance for LULUCF (Land Use, Land Use Change and Forestry) and the IPCC Working Group I, Fourth Assessment Report, Second Order Draft. Please don't rely on them for legal or other official reasons without checking that you have the up-to-date versions.

ABOVEGROUND BIOMASS - All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.

ACTIVITY - A practice or ensemble of practices that take place on a delineated area over a given period of time.

ACCOUNTING - The rules for comparing emissions and removals as reported with commitments.

ACCU - Australian carbon credit unit. May be either a Kyoto Australian carbon credit unit or a non-Kyoto Australian carbon credit unit, depending whether the sequestration or emissions avoidance meets Australia's commitments under the Kyoto Rules.

ACCURACY - Inventory definition: Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, so far as can be judged, and that uncertainties are reduced so far as is practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories. (FCCC/SBSTA/1999/6/Add.1)
Statistical definition: Accuracy is a general term which describes the degree to which an estimate of a quantityis unaffected by bias due to systematic error. It should be distinguished from precision as illustrated below.

ACTIVITY BASED CARBON CONTRACTS - Contracts that are based on predictive models or methods of measurement that simulate carbon offsets accomplished through specific management practices that reduce emissions or sequester carbon. For example, it is estimated that farmers engaged in NoTill/Direct Seeding or Strip Till sequester conservatively 0.5 Tons of CO_2 per acre per year by engaging in these practices.

ACTIVITY DATA - Inventory definition: Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. In the LULUCF sector, data on land areas, management systems, lime and fertilizer use are examples of activity data.

ADDITIONALITY - **O**ne of the criteria that is used to measure quality and eligibility of a project or practice to qualify as an emissions offset. Additionality is the industry term for going beyond "business as usual" (BAU), i.e. to qualify as an offset, the emissions reductions from projects or practices must be additional to what would exist if the project or practices were not carried out.

AFFORESTATION - The direct human-induced convers-ion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.

AGGREGATOR - An entity that serves as the administrative representative to pool the efforts of offset project owners for one or multiple offset-generating projects or practices.

ANTHROPOGENIC - Man-made, resulting from human activities. In the IPCC guidelines, anthropogenic emissions are distinguished from natural emissions. Many of the greenhouse gases are also emitted naturally. It is only the man-made increments over natural emissions which may be perturbing natural balances. In this LULUCF-GPG, all emissions and removals of managed lands are seen as anthropogenic.

BELOWGROUND BIOMASS - All living biomass of live roots. Fine roots of less than (suggested) 2mm diameter are sometimes excluded because these often cannot be distinguished empirically from soil organic matter or litter.

BIOMASS - Organic material both aboveground and belowground, and both living and dead, e.g., trees, crops, grasses, tree litter, roots etc. Biomass includes the pool definition for above - and below-ground biomass.

BIOMASS ACCUMULATION RATES
Net build up of biomass, i.e., all

increments minus all losses. When carbon accumulation rate is used, only one further conversion step is applied: i.e., the use of 50% carbon content in dry matter (default value).

BASELINE AND BASELINE SCENARIO - The baseline represents forecasted emissions under a business-as-usual (BAU) scenario, often referred to as the 'baseline scenario' , i.e. expected emissions if the emission reduction activities were not implemented.

BOTTOM-UP MODELLING
A modelling approach which starts from processes at a detailed scale (i.e., plot/stand/ecosystems scale) and provides results at a larger, aggregated scale (regional/national/continental/global) .

CANOPY COVER -The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants. Cannot exceed 100%. (Also called crown closure)

CAP-AND-TRADE - Term for legislation that deals with capping allowed emissions and allowing a trading scheme to meet emission caps. Under a "capped-uncapped" system (like that currently in place among EU nations) greenhouse gas emissions from the major energy sectors are limited or capped, while those in other sectors, most notably land use sectors including agriculture and forestry, are not capped. In such a market, the energy (emitter) sector becomes the principle buyer, or demander, of carbon credits. Uncapped sectors (including agriculture and others who can generate emissions offset projects) become a supplier of greenhouse gas offsets, or carbon credits, for purchase by entities seeking to meet or comply with their caps. Until there is a cap on emissions, emitters only reason to purchase carbon credits is to appear environmentally responsible on a voluntary basis. The market value that emitters are willing to pay for carbon in the US has been in the $1-4/Ton range, while values in other parts of the world where emission caps are driving value have resulted in carbon trading in the ranges of $10-30/ton of CO2.

CARBON BUDGET- The balance of the exchanges of carbon between carbon pools or between one specific loop (e.g., atmosphere –biosphere) of the carbon cycle. The examination of the budget of a pool or reservoir will provide information whether it is acting as a source or a sink.

CARBON CYCLE - All parts (pools) and fluxes of carbon; usually thought of as a series of the four main pools of carbon interconnected by pathways of exchange. The four pools are atmosphere, biosphere, oceans and sediments. Carbon exchanges from pool to pool by chemical, physical and biological processes.

CARBON FLUX - Transfer of carbon from one pool to another in units of measurement of mass per unit of area and time (e.g., tonnes C ha-1 yr-1).

CARBON MAINTENANCE OBLIGATION – A carbon maintenance obligation prevents a person from engaging in conduct that results or is likely to result in a reduction in carbon stores below the benchmark sequestration level, unless the conduct relates to an activity that has been expressly permitted in the declaration The purpose of a carbon maintenance obligation is to protect carbon stores in circumstances where the project proponent has not or is unlikely to hand back credits as required. A carbon maintenance obligation `runs with the land' and will therefore apply to future land owners.

CARBON OFFSET
Offsetting is a term associated with avoiding a carbon emission in one location by implementing an emissions reduction project (or practice) in another location. A carbon offset is the net reduction in carbon emissions resulting from the avoidance of a tonne of CO2 *(CDM Gold Standard)*. A carbon offset could also arise from practices that sequester carbon.

CARBON POOL - The reservoir containing carbon.

CARBON DIOXIDE EQUIVALENT (CO2-e) - A measure used to compare different greenhouse gases based on their global warming potentials (GWPs). The GWPs are calculated as the ratio of the radiative forcing of one kilogramme greenhouse gas emitted to the atmosphere to that from one kilogramme CO2 over a period of time (usually 100 years).

CARBON NEUTRAL - Zero CO2 emissions from sources, which are currently not addressed, or only inadequately addressed, by climate policies (e.g. private households, public administrations, most small and medium sized businesses, air travel). Carbon neutrality is a voluntary market mechanism to encourage the reduction of emissions.

CARBON SEQUESTRATION - This is the net process of storing carbon in a carbon sink. Sinks can include terrestrial (soil, trees), oceanic, atmospheric, and geologic. For example, terrestrial sequestration could result when carbon fixed in trees through aforestation, or plants and soil root masses as a result of NoTill practices results in photosynthesis exceeding carbon dioxide release through plant aspiration.

CARBON STOCK - The quantity of carbon in a pool.

CCX - Chicago Climate Exchange is the U. S. first public greenhouse gas registry, reduction and trading system. Members make a legally but binding commitment to reduce GHG emissions. By the end of Phase I (December, 2006) all members were to have reduced emissions 4% below a baseline period of 1998-2001. Phase II, which extends the CCX reduction program through 2010, requires all members to reduce GHG emissions 6% below the baseline.

CLEAN DEVELOPMENT MECHANISM (CDM) - An arrangement under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment (called Annex B countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. A crucial feature of an approved CDM carbon project is that it has established that the planned reductions would not occur without the additional incentive provided by emission reductions credits, a concept known as "additionality". The CDM allows net global greenhouse gas emissions to be reduced at a much lower global cost by financing emissions reduction projects in developing countries where costs are lower than in industrialized countries. However, in recent years, criticism against the mechanism has increased. The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC).

CLOSED FORESTS
Forests characterised by canopy cover higher than 40%.

COEFFICIENT OF VARIATION - Statistical definition: The coefficient of variation, vx is the ratio of the population standard deviation, £mx, and mean, µx, where vx = £mx /µx. It also frequently refers to the sample coefficient of variation, which is the ratio of the sample standard deviation and sample mean. ‘Coefficient of variation’ is the term, which is frequently replaced by ‘error’ in a statement like ‘the error is 5%’.

CONFIDENCE - Inventory

definition: The term ‘confidence’ is used to represent trust in a measurement or estimate. Having confidence in inventory estimates does not make those estimates more accurate or precise; however, it will eventually help to establish a consensus regarding whether the data can be applied to solve a problem. This usage
of confidence differs substantially from the statistical usage in the term confidence interval.

CONFIDENCE INTERVAL - Statistical definition: A confidence interval is the range in which it is believed that the true value of a quantity lies. The level of belief is expressed by the probability, whose value is related to the size of the interval. It is one of the ways in which uncertainty can be expressed (see estimation, statistical definition). In practice a confidence interval is defined by a probability value, say 95%, and confidence limits on either side of the mean value x. In this case the confidence limits L1 and L2 would be calculated from the probability density function such that there was a 95% chance of the true value of the quantity being estimated by x lying between L1 and L2. Commonly L1 and L2 are the 2.5 percentile and 97.5 percentile respectively. Example: ‘An emission is between 90 and 100 kt with a probability of 95%.’ Such a statement can be provided when the confidence interval is calculated (the numerical values in this example are arbitrarily chosen).

CONVERSION
Change of one land use to another.

CROPLAND - This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the threshold used for the forest land category, consistent with the selection of national definitions.

CROPLAND MANAGEMENT - The system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production.

DEFORESTATION - The direct human-induced conversion of forested land to non-forested land.

DISTURBANCES - Processes that reduce or redistribute carbon pools in terrestrial ecosystems.

DOIC - Domestic Offsets Integrity Committee - An independent expert committee established to assess proposed methodologies and make recommendations to the Minister for Climate Change and Energy Efficiency on their approval. The DOIC will ensure that methodologies are rigorous and lead to real and verifiable abatement.

DROUGHT* - In general terms, drought is a "prolonged absence or marked deficiency of precipitation", a "deficiency that results in water shortage for some activity or for some group," or a "period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance". Drought has been defined in a number of ways. Agricultural drought relates to moisture deficits in the topmost metre or so of soil (the root zone) that impacts crops, meteorological drought is mainly a prolonged deficit of precipitation, and hydrologic drought is related to below normal streamflow, lake and groundwater levels.

EMISSIONS - The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.

EMISSION FACTOR - Inventory definition: A coefficient that relates the activity data to the amount of chemical compound which is the source of later emissions. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

ERROR
Statistical definition: In statistical usage, the term 'error' is a general term referring to the difference between an observed (measured) value of a quantity and its 'true' (but usually unknown) value and does not carry the (pejorative) sense of a mistake or blunder.

ESTIMATION - Inventory definitions: The process of calculating emissions. Statistical definition: Estimation is the assessment of the value of a quantity or its uncertainty through the assignment of numerical observation values in an estimation formula, or estimator. The results of an estimation can be expressed as follows:

• a point estimation which provide a number which can be used as an approximation to a parameter (such as the sample standard deviation which estimates the population standard deviation), or
• an interval estimate specifying a confidence level.

Example: A statement like 'The total emission is estimated to be 100 kt and its coefficient of variation is 5%' is based
upon point estimates of the sample mean and standard deviation, whereas a statement such as 'The total emission lies
between 90 and 110 kt with probability 95%' expresses the

results of estimation as a confidence interval.

EXPERT JUDGEMENT-Inventory definition: A carefully considered, well-documented qualitative or quantitative judgement made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field.

EU-ETS - Abbreviation for European Union-Emissions Trading Scheme. The EU-ETS is the oversight entity under which pilot-project based carbon trading is being conducted in European Union signatories seeking to comply with the Kyoto Protocol. The pilot project period began in 2003 and will go through 2007. The official period for Kyoto emissions reduction measurement is set for 2008-2012. EU-ETS is the largest GHG emissions cap and trade system in the world, involving multiple countries and sectors. Under this Scheme, electrical and industrial installations must obtain a CO2 permit, monitor emissions, and ensure emissions do not exceed the European Union Emissions Allowances (EUAs) that each holds. The system is patterned after the U. S. sulfur dioxide emissions cap and trade program which has been highly successful in reducing SO2 emissions.

EUA - European Union Emission Allowance

FOREST - Forest is a minimum area of land of 0.05 – 1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10 – 30 per cent with trees with the potential to reach a minimum height of 2 – 5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10 – 30 per cent or tree height of 2 – 5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest. Remark: Forests are not defined for reporting under the Convention. The IPCC Guidelines encourage countries to use detailed ecosystem classifications in the calculations and in reporting broad specified categories to ensure consistency and comparability of national data across countries. *(Australia's definition of a 'forest' for Kyoto Protocol purposes is a forest of trees: with a potential height of at least 2 metres, with crown cover of* *at least 20 per cent, in patches greater than 0.2 hectares in area.)*

FUNGIBILITY
Possibility to exchange different types of reduction credits achieved under different mechanism (e.g. ERUs on AAUs etc.).

GEOLOGIC SEQUESTRATION
Sequestration that is achieved by pumping CO2 into subterranean permanent reservoirs such as basalt formations and deep wells. Geologic sequestration is considered to be a more permanent form of GHG offset and has significant potential for longer term sequestration, but it is very costly to implement compared to terrestrial sequestration alternatives.

GHG - Abbreviation for Green House Gases; "greenhouse effect" refers to the temperature regulation effect that certain atmospheric gases have on the earth. Temperature-regulating gases, called "greenhouse gases" or GHGs, form a blanket around the earth that traps heat from the sun within the earth's atmosphere, keeping the planet warm and habitable. "Global warming," or climate change, can occur when the blanket of GHGs gets thicker. Climate models from the Intergovernmental Panel on Climate Change, as well as models from other scientific bodies, indicate that global concentrations of GHGs have been rising steadily over the past 100 years. As atmospheric concentrations of GHGs increase, the greenhouse blanket gets thicker. This causes heat to be trapped in the lower layers of the atmosphere and may cause global average temperatures to rise (source: CCX FAQs). Common green house gases include CO2, Nitrous Oxide (NO2) Chlorofluorocarbons (CFCs), and methane (CH4). Global warming impacts of each of these gases differ significantly. CO2, the most common GHF, is assigned an index value = 1. Index values for CH4 = 24; NO2 = 310; HFCs = 150; PFCs = 6500.

GLOBAL WARMING POTENTIAL (GWP) - The global warming potential is the impact a greenhouse gas (GHG) has to global warming. By definition, CO2 is used as reference case, hence it always has the GWP of 1. GWP changes with time, and the IPCC has suggested using 100-year GWP for comparison purposes. Below is a list of 100-year GWPs:

Carbon dioxide (CO2) GWP: 1
Methane (CH4) GWP: 24
Nitrous oxide (N2O) GWP: 310
Hydrofluorcarbons (HFCs) GWP: GWP: 150 – 11 700
Perfluorcarbons (PFCs) GWP: 6500 – 9 200
Sulphur hexafluoride (SF6) GWP: 23 900

GOLD STANDARD

The *Gold Standard* based in Basel, Switzerland, is a foundation, a project development method, and a credit label. Endorsed by 42 non-governmental organizations (NGOs) worldwide, it offers a quality label to CDM/JI and voluntary GHG offset projects. It issues credits in the voluntary market but only covers renewable energy and energy efficiency projects; it does not get involved in carbon sequestration projects (i.e. agriculture and forestry). Gold Standard is not a verifier. *(see www.cdmgoldstandard.org)* In the U. S. the *Gold Standard* is a manual that was been developed by Duke University. It establishes protocols for measuring or quantifying offsets generated by changing land uses and practices.

GOOD PRACTICE - Inventory definition: Good Practice is a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over nor underestimates so far as can be judged, and that uncertainties are reduced so far as possible.

Good Practice covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties and data archiving and reporting to promote transparency.

GRASSLAND - This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and is not expected to exceed, without human intervention, the thresholds used in the forest land category. This category also includes all grassland from wild lands to recreational areas as well as agricultural and silvo-pastural systems, subdivided into managed and unmanaged, consistent with national definitions.

GRAZING LAND MANAGEMENT - The system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.

GROUND TRUTH - A term used for data obtained by measurements on the ground, usually as validation for, e.g., satellite data.

HIGH ACTIVITY CLAY (HAC) SOILS - Soils with high activity clay (HAC) minerals are lightly to moderately weathered soils which are dominated by 2:1 silicated clay minerals (in FAO classification included: Vertisols, Chernozems, Phaezems, Luvisols).

HUMUS - Humus is a key component in the soil profile that stores water, holds soil particles together and provides a healthy environment for microorganisms to aid in nutrient exchange and plant growth. Organic Matter is not all humus. Humus takes thousands of years to build in the soil through decomposition of soil residues. Humus has a carbon:nitrogen ratio of 10:1. For example, wheat straw has an 80:1 ratio, and when it breaks down in the soil, it converts to organic matter at a 30:1 C:N ratio. Understanding humus and organic matter dynamics is critical to understanding CO2 release and sequestration as well as nutrient release and replenishment strategies dictated by intensive versus reduced tillage cropping systems. Understanding these dynamics is also important in understanding nitrogen requirements associated with building carbon in the soil profile.

IMPROVED PASTURES/GRASSLAND/ RANGELAND - Land subject to intensive, controlled grazing often subject to fertilisation and/or regular re-establishment of the grass cover.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) - IPCC was established by World Meteorological Organisation (WMO) and the United Nations Environmental Programme (UNEP) in 1988 to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. It is open to all Members of the UN and of WMO (www.ipcc.ch).

KEY CATEGORY - A category that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both.

KYOTO PROTOCOL – The Kyoto protocol resulted from the United Nations Framework Convention on Climate Change held in Kyoto, Japan in December of 1997. It proposed a process for establishing quantitative, enforceable limits on the emission of greenhouse gases to the Earth's atmosphere. It also contained negotiated commitments by 38 developed countries and countries in transition to reduce emissions 7% below 1990 baseline levels for the period 2008-2012. The protocol called for reductions in fossil fuel consumption by improving the efficiency of energy use and by developing renewable source of energy and identifying sinks and increasing rates of carbon sequestration. The protocol prescribed that countries could remove GHG CO2 from the atmosphere into living plants, sequester carbon in the terrestrial biosphere, and use the sequestered carbon to offset some of the greenhouse gas emissions from other sources. The protocol provided for an emissions trading process where an emitting country could meet emissions requirement in part by trading with another country performing an emissions reduction activity, but the protocol was silent on eligibility of carbon sequestration projects to offset emissions-reductions requirements.

The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro, Brazil, from 3–14 June 1992. The treaty is intended to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The Kyoto Protocol establishes legally binding commitments for the reduction of four greenhouse gases (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride), and two groups of gases (hydrofluorocarbons and perfluorocarbons) produced by "Annex I" (industrialized) nations, as well as general commitments for all member countries. As of 2008[update], 183 parties have ratified the protocol, which was initially adopted for use on 11 December 1997 in Kyoto, Japan and which entered into force on 16 February 2005. Under Kyoto, industrialized countries agreed to reduce their collective GHG emissions by 5.2% compared to the year 1990. National limitations range from 8% reductions for the European Union and some others to 7% for the United States, 6% for Japan, and 0% for Russia. The treaty permitted GHG emission increases of 8% for Australia and 10% for Iceland.[3]

Kyoto includes defined "flexible mechanisms" such as Emissions Trading, the Clean Development Mechanism and Joint Implementation to allow Annex I economies to meet their greenhouse gas (GHG) emission limitations by purchasing GHG emission reductions credits from elsewhere, through financial exchanges, projects that reduce emissions in non-Annex I economies, from other Annex I countries, or from Annex I countries with excess allowances. In practice this means that Non-Annex I economies have no GHG emission restrictions, but have financial incentives to develop GHG emission reduction projects to receive "carbon credits" that can then be sold to Annex I buyers, encouraging sustainable development.[4] In addition, the flexible mechanisms allow Annex I nations with efficient, low GHG-emitting industries, and high prevailing environmental standards to purchase carbon credits on the world market instead of reducing greenhouse gas emissions domestically. Annex I entities typically will want to acquire carbon credits as cheaply as possible, while Non-Annex I entities want to maximize the value of carbon credits generated from their domestic Greenhouse Gas Projects.

KYOTO UNITS: An assigned amount unit, a certified emission reduction, an emission reduction unit, a removal unit or a prescribed unit issued in accordance with the Kyoto rules.

LAND COVER - The type of vegetation covering the earth's surface.

LAND USE - The type of activity being carried out on a unit of land.

LEAKAGE - A term used to describe the emission of CO2 as a result of the production cycle. Forestry and agriculture emit CO2 in the process of growing trees and agricultural crops through their use of fertilizers, equipment, power, fire (prescribed and wildfire), and vegetative decomposition.

LITTER - Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for example 10 cm), lying dead, in various states of decomposition above the mineral or organic soil. This includes litter, fumic, and humic layers. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included in litter where they cannot be distinguished from it empirically.

LOW ACTIVITY CLAY (LAC) SOILS - Soils with low activity clay (LAC) minerals are highly weathered soils dominated by 1:1 clay mineral and amorphous iron and aluminium oxides (in FAO classification included: Acrisols, Nitosols, Ferrasols).

MANAGED GRASSLAND - Grasslands on which human-induced activities are carried out, such as grazing or hay removal.

METADATA - Information about data; i.e., the description of which parameters and variables are stored in a database: their location, time of recording, accessibility, representativeness, owner, etc.

OFFSET METHODOLOGY –

Offsets projects established under the CFI will need to use approved methodologies. These will contain the detailed rules for implementing and monitoring specific abatement activities under the scheme. Methodologies can be developed and proposed by private proponents, as well as government agencies. Approved methodologies can be used by anyone undertaking a similar project. Methodology determinations contain project-specific rules and eligibility requirements. Methodology determinations must apply to specified kinds of offsets projects. This will ensure that methodologies can be applied by other project proponents in comparable circumstances. The fact that methodologies can be used by anyone with a similar project will reduce participation costs.

MODEL -Statistical definition: A model is a quantitatively-based abstraction of a real-world situation which may simplify or neglect certain features to better focus on its more important elements.

MONTE CARLO METHOD - Inventory definition: The principle of Monte Carlo analysis is to perform the inventory calculation many times by electronic computer, each time with the uncertain emission factors or model parameters and activity data chosen randomly (by the computer) within the distribution on uncertainties specified initially by the user.
Uncertainties in emission factors and/or activity data are often large and may not have normal distributions. In this case the conventional statistical rules for combining uncertainties become very approximate. Monte Carlo analysis can deal with this situation by generating an uncertainty distribution for the inventory estimate that is consistent with the input uncertainty distributions on the emission factors, model parameters and activity data.

MMV - Abbreviation for the carbon contract administration processes known as Measurement, Monitoring and Verification. MMV can result in significant cost outlays to administer carbon contracts related to terrestrial sequestration (NoTill, grazing/CRP, reforestation /Aforestation, etc.). MMV costs can exceed the market value of the carbon offsets, if sellers are forced to measure, monitor and verify actual field results of their management activity to create the offsets. For this reason, sellers of terrestrial-based carbon offsets have continued to support development and refinement of predictive modeling systems whose goals are to accurately duplicate the results that would be found from actual field measurements.

NETANNUAL INCREMENT
Average annual volume over the given reference period of gross increment minus natural mortality, of all trees to a specified minimum diameter at breast height.

NET-NET ACCOUNTING
The carbon sink or source in the reporting year minus the carbon sink or source in the base year. This is the accounting method for grazing land management, cropland management and revegetation under Article 3.4.

NO-TILL - Term used to describe a system of establishing a crop that minimizes the amount of soil disturbance required and maximizes efforts to retain the integrity of residue on the soil surface. The term "NoTill" is used interchangeably with the terms Zero Till and Direct Seeding throughout the world. NRCS Conservation Practice Standard 329 includes a combined definition for NoTill/Strip Till/Direct Seed as follows: "Managing the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops."

OCEAN SEQUESTRATION
- Carbon dioxide capture and storage system that includes both injection into deep areas of the ocean and increased stimulation of ocean surface waters to grow phytoplankton and take up carbon dioxide.

OFFSET PROVIDER - An owner of an offset project that either registers a project directly on a tradable exchange or offers the offset project for trading through an aggregator.

OPEN FORESTS - Forests characterised by crown cover between 10 and 40% (FAO), or below the canopy cover threshold as adopted by the Party.

ORGANIC SOILS - Soils are organic if they satisfy the requirements 1 and 2, or 1 and 3 below (FAO, 1998):
1. Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 percent or more organic carbon
when mixed to a depth of 20 cm;
2. If the soil is never saturated with water for more than a few days, and contains more than 20 percent (by weight) organic carbon (about 35 percent organic matter);
3. If the soil is subject to water saturation episodes and has either:
(i) At least 12 percent (by weight) organic carbon (about 20 percent organic matter) if it has no clay; or
(ii) At least 18 percent (by weight)

organic carbon (about 30 percent organic matter) if it has 60 percent or more clay; or
(iii) An intermediate, proport-ional amount of organic carbon for intermediate amounts of clay.

PASTURE - Grassland managed for grazing.

PEAT SOIL (ALSO HISTOSOL) - A typical wetland soil with a high water table and an organic layer of at least 40 cm thickness (poorly drained organic soil).

PERFORMANCE BASED CONTRACTS - Contracts that are based on actual performance achieved as measured by actual field testing or measurement models that determine actual amounts of carbon offsets accomplished through specific management practices that reduce emissions or sequester carbon. For example, farmers engaged in NoTill/Direct Seeding or Strip Till in highly productive farming regions with high rainfall and residue intensive crop rotations might sequester 1.0 Tons of CO_2 per acre per year as a direct result of engaging in these cropping system practices. Whereas a farm in a low rainfall area with light, sandy soils, low organic matter, and limited viability of alternative rotation crops may only sequester 0.25 Tons of CO_2 per acre per year from the same practices.

PERENNIAL CROPS - Multiple year crops, includes trees and shrubs, in combination with herbaceous crops e.g., agroforestry, or orchards, vineyards and plantations such as cocoa, coffee, tea, oil palm, coconut, rubber trees, and bananas, except where these lands meet the canopy cover threshold criteria for forest land.

PERMANENCE - A criteria that is used to measure quality and eligibility of a project or practice to qualify as an emissions offset; this criteria measures whether the offset is temporary or permanent in nature.
POOL/CARBON POOL - A reservoir. A system which has the capacity to accumulate or release carbon. Examples of carbon pools are forest biomass, wood products, soils and the atmosphere. The units are mass.

PRECISION - Inventory definition: Precision is the inverse of uncertainty in the sense that the more precise something is, the less uncertain it is. Statistical definition: Closeness of agreement between independent results of measurements obtained under stipulated conditions (see also accuracy).

PROPAGATION OF UNCERTAINTIES

Statistical definition: The rules for propagation of uncertainties specify how to algebraically combine the quantitative measures of uncertainty associated with the input values to the mathematical formulae used in inventory compilation, so as to obtain corresponding measures of uncertainty for the output values.

PROJECT PROPONENT – The person who is responsible for carrying out a project and has the legal right to carry out the project. If the project is a sequestration offsets project, the proponent must also hold the applicable sequestration right in relation to the project area or areas.

RADAR DATA - Remotely-sensed data from the microwave portion of the electromagnetic spectrum, sent from and collected by aircraft or satellite after reflection from the target.

RASTER DATA - Information stored on regular grid of points.

RASTER IMAGES - Raster data means information stored on a regular grid of points, as opposed to polygon data, which is information stored as the coordinates of an outline area sharing a common attribute.

REMOTE SENSING - Practice of acquiring and using data from satellites and aerial photography to infer or measure land cover/use. May be used in combination with ground surveys to check the accuracy of interpretation.

REPORTING - The process of providing estimates to the UNFCCC.

RESOLUTION - Smallest unit of land about which land cover or use can be determined. High resolution means the resolvable land units are small.

REVEGETATION - A direct human-induced activity to increase carbon stocks on sites throught the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation contained here.

SAMPLE - Statistical meaning: A sample is a finite set of observations drawn from a population.

SANDY SOILS - Includes all soils (regardless of taxonomic classification) having > 70% sand and < 8 % clay (based on standard textural measurements (in FAO classification include: Arenosols, sandy Regosols)).

REGISTRY - Advocates for developing audited approaches to carbon trading are endorsing registration of carbon credit sales or emissions offset sales so buyers and sellers. EcoRegistry (ERT) is one example.

SEQUESTRATION - The process of increasing the carbon content of a carbon pool other than the atmosphere. It is preferred to use the term "sink".

SINK - Any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere. Notation in the final stages of reporting is the negative (-) sign.

SOC - Soil Organic Carbon is a key measurement indicator of soil quality, normally state as % of Soil Organic Matter (SOM). It is normally obtained by taking soil samples and indicates the % of soil carbon in a specific layer of soil (i.e. 2.0% SOM in top 6 inches of soil profile). This indicator is important both as to quantity as well as relatively where it is concentrated in the soil profile. The most active area for plant growth and nutrient exchange is the top 4-6"; consequently that is why soil organic matter testing usually focuses on measurements in this layer.

SOIL ORGANIC MATTER
Includes organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included with soil organic matter where they cannot be distinguished from it empirically.

SOURCE - Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere. Notation in the final stages of reporting is the positive (+) sign.

SPATIAL INTERPOLATION
Inference about the characteristics of land from known information on surrounding land locations.

SPATIALLY EXPLICIT - Mapped or otherwise geographically referenced.

STRIP TILL - Term used to describe a system of establishing a crop that minimizes the amount of soil disturbance and maximizes efforts to retain the integrity of residue on the soil surface. Strip Till differs from NoTill/Direct Seed. It normally involves a fall tillage operation that clears residue in the target seed zone, places soil in a ridge to aid in drying and soil warmth to facilitate seeding at a later date, and may or may not include a fertilizer placement. A second operation at seeding time places seed (and usually additional fertilizer) in the ridged seed zone, usually with the aid of Precision Farming technology.

TERRESTRIAL SEQUESTRATION - Sequestration that is associated with capturing and storing carbon in plant and soil structures. Terrestrial sequestration is commonly achieved through such practices as NoTill/Strip Till/Direct Seeding, grassland seeding, forestation and aforestation.

SYSTEMATIC AND RANDOM ERRORS - Statistical definition: Systematic error is the difference between the true, but usually unknown, value of a quantity being measured, and the mean observed value as would be estimated by the sample mean of an infinite set of observations. The random error of an individual measurement is the difference between an individual measurement and the above limiting value of the sample mean.

TOP-DOWN MODELLING
A modelling approach which aims to infer processes and parameters at a smaller scale from measurements taken at an aggregated scale (regional/national/continental/global).

TRANSPARENCY - Inventory definition: Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information.

UNCERTAINTY - Statistical definition: An uncertainty is a parameter, associated with the result of measurement that characterises the dispersion of the values that could be reasonably attributed to the measured quantity (e.g., the sample variance or coefficient of variation). Inventory definition: A general and imprecise term which refers to the lack of certainty (in inventory components) resulting from any causal factor such as unidentified sources and sinks, lack of transparency, etc.

UNCERTAINTY ANALYSIS
Statistical definition: An uncertainty analysis of a model aims to provide quantitative measures of the uncertainty of output values caused by uncertainties in the model itself

and in its input values, and to examine the relative importance of these factors.

UNFCCC - United Nations Framework Convention on Climate Change (see www.unfcc.int.org) United Nations Framework Convention on Climate Change (UNFCCC or FCCC) is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro from 3 to 14 June 1992. The treaty is aimed at stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The treaty as originally framed set no mandatory limits on greenhouse gas emissions for individual nations and contained no enforcement provisions; it is therefore considered legally non-binding. Rather, the treaty included provisions for updates (called "protocols") that would set mandatory emission limits. The principal update is the Kyoto Protocol, which has become much better known than the UNFCCC itself. One of its first achievements was to establish a national greenhouse gas inventory, as a count of greenhouse gas (GHG) emissions and removals. Accounts must be regularly submitted by signatories of the United Nations Framework Convention on Climate Change.

VALIDATION - Inventory definition: Validation is the establishment of sound approach and foundation. In the context of emission inventories, validation involves checking to ensure that the inventory has been compiled correctly in line with reporting instructions and guidelines. It checks the internal consistency of the inventory. The legal use of validation is to give an official confirmation or approval of an act or product.

VARIABILITY - Statistical definition: This refers to observed differences attributable to true heterogeneity or diversity in a population. Variability derives from processes which are either inherently random or whose nature and effects are influential but unknown. Variability is not usually reducible by further measurement or study, but can be characterised by quantities such as the sample variance.

VERs - Verified Emission Reduction; a standard measure of emission reductions in the EU market.

VERIFICATION - Inventory

definition: Verification refers to the collection of activities and procedures that can be followed during the planning and development, or after completion of an inventory that can help to establish its reliability for the intended applications of that inventory. Typically, methods external to the inventory are used to check the truth of the inventory, including comparisons with estimates made by other bodies or with emission and uptake measurements determined from atmospheric concentrations or concentration gradients of these gases.

VOLUNTARY MARKET - Voluntary markets for emissions reductions cover those buyers and sellers of Verified Emission Reductions (VERs), which seek to manage their emission exposure for non-regulatory purposes.

VOLUNTARY CARBON STANDARD - The Voluntary Carbon Standard (VCS) is a quality standard for voluntary carbon offset industry. Based on the Kyoto Protocol's Clean Development Mechanism, VCS establishes criteria for validating, measuring, and monitoring carbon offset projects.

WALL-TO-WALL MAPPING
Complete spatial coverage of a land area, e.g., by satellite data.

WETLANDS - This category includes land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories.

ZERO TILL - Term used to describe a system of establishing a crop that minimizes the amount of soil disturbance and maximizes efforts to retain the integrity of residue on the soil surface. The term "NoTill" is used interchangeably with the terms, Zero Till and Direct Seeding throughout the world.

Soil Carbon & Food Security

"We need to be able to grow double the amount of food on two thirds of the water, which means you've got to increase by around about 200 per cent the amount of water efficiency of the crop, which is a very steep challenge to most countries."

Professor Julian Cribb, Adjunct Professor of Science Communication at the University of Technology Sydney on Radio National, 23rd April, 2008

Acronyms

ABARE Australian Bureau of Agricultural and Resource Economics
ACCU Australian Carbon Credit Unit
ASCAS Australian Soil Carbon Accreditation Scheme
ASFA Australian Fertiliser Services Association
ASRIS Australian Soil Resource Information System
ASX Australian Stock Exchange
ATO Australian Taxation Offices
AWI Australian Wool Innovation Limited
BoM Bureau of Meteorology
BRS Bureau of Rural Sciences
CAAANZ Conservation Agriculture Alliance of Australia and New Zealand
CDM clean development mechanism
CEC cation exchange capacity
CFI Carbon Farming Initiative
CMA catchment management authority
CO2 e carbon dioxide equivalents
CRC cooperative research centre
CRC FFI Cooperative Research Centre (CRC) for Future Farm Industries
CSIRO Commonwealth Scientific and Industrial Research Organisation
CSU Charles Sturt University
CT conventional tillage
CTF controlled traffic farming
DA Dairy Australia

DAFF Australian Government Department of Agriculture, Fisheries and Forestry
DAFWA Department of Agriculture and Food, Western Australia
DOFA Department of Finance and Administration
DOIC Domestic Offsets Integrity Committee
DOM dissolved organic matter
DPI Victoria Department of Primary Industries, Victoria
DSE dry sheep equivalent
EMS environmental management system
GHG greenhouse gases
GMO genetically modified organism
GRDC Grains Research and Development Corporation
IP intellectual property
JV joint venture
LWA Land and Water Australia
MIR midinfrared
MLA Meat and Livestock Australia
MMV measurement monitoring and verification
N2O nitrous oxide
NFF National Farmers' Federation
NIR near infrared
NRM natural resource management
NSWDPI New South Wales Department of Primary Industries
OC organic carbon
OM organic matter
PAW plant available water
PAWC plant available water capacity
POC particulate organic carbon

POM particulate organic matter
QA quality assurance
QC quality control
RIRDC Rural Industries Research and Development Corporation
SANTFA South Australian No Till Farmers Association
SOC soil organic carbon
SOI Southern Oscillation Index
SOM soil organic matter
USDA United States Department of Agriculture
UWA University of Western Australia
Victoria DPI Department of Primary Industries
VNFTA Victorian No-Till Farmers Association
WANTFA Western Australian No Tillage Farmers Association
ZT zero tillage

> ***Professor Rattan Lal quotes a US Federal Bureau of Soils document which maintained in 1878 "the soil is the one indestructable, immutable asset that the nation possess, and one resource that cannot be exhausted." This attitude led to the legendary dust storms when the mid-West of the USA lost thousands of***

Soils, Food and Human Health: It's Personal

In April 2001 I was healthy and fit and was suddenly struck down by an illness where I lost all muscle control, experienced chronic headaches, couldn't eat solid food and slept about 20 hours a day. Doctors would keep sending me home telling me 'I had a virus', finally after seven weeks of being in bed I was admitted to hospital and my husband had been told by the doctor that 'I may not pull through'.

Rhonda Daly

Tests revealed that I had been suffering spinal meningitis for the seven weeks in which time I had lost 90% of my hearing and 50% of my vision. Those seven weeks were a time where I suffered both physically as well as emotionally, and found myself pondering my purpose in life, laying in bed. During this time of questioning and pondering I was 'guided' that I had to 'heal the soils and help others'. My husband Bill and I decided to follow this message and change our farming practices on Milgadara as well as assist other farmers adopt more sustainable farming practices and use biological fertilisers.

Prior to my illness I realised that the quality of our food had degraded since the instigation of chemical agriculture but had not truly linked soil health to food health. After my guided message I realised the importance of a healthy living soil to produce nutrient dense food with less chemicals.

Our agricultural soils have become more and more depleted of essential minerals, both macro and minor trace elements as well as they lack micro-biology that play a vital role in creating good soil structure, nutrient cycling, and detoxifying the soils and producing healthy nutrient dense food. Dr Ian Brightthorpe MD relates the problem of cancer to depleted soils. When a plant is grown on depleted lifeless soils the only way to feed the plant is by supplying soluble chemical fertilisers, such as nitrate nitrogen, which are devoid of balanced nutrients and essential trace minerals. Nitrate Nitrogen is a known human castrogen.

With a weak, ailing plant, insects and diseases come in to 'take out' ill plants. Agricultural multi-nationals have an array of 'bandaids' to use to kill the insects and wipe out the disease. However when these chemicals are sprayed over our land they are non-selective in what they kill, wiping out the good and bad guys and probably us as well. YLAD is committed to supplying truly sustainable natural products that make the earth to a healthier place by producing high grade Humus Compost and supplying biological fertilisers to farmers to turn soil back into a functional, minerally dense, living eco-system.

I have seen over the years how hundreds of farmers have taken up the challenge of converting from chemical agriculture to biological agriculture and reap the rewards both emotionally, mentally and financially. I believe that, if you work with nature, nature will reward you.

YLAD Living Compost is a major sponsor of The Carbon Farming Handbook

Bill and Rhonda Daly are great supporters of the Soil Carbon Movement. They are major sponsors of The Carbon Farming Handbook, and the Carbon Farming Conference. Sponsorship and Advertising Packages are available for companies and individuals wishing to support the lobbying and educational work of the Carbon Coalition and Carb-on Farmers of Australia.

Michael Kiely with Bill & Rhonda Daly at a YLAD Composting Workshop. The Dalys bring many US experts out to add their expertise to the home grown knowledge of Australian farmers.

This Publication was made possible by the generous support of these fine companies:

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