Colloquium

The Back Forty Down Under:
Adapting Farming to Climate Variability

by Christine Jones, Ph.D.

The financial viability of the agricultural sector, as well as the health and social wellbeing of individuals, families and businesses in both rural and urban communities, are inexorably linked to the functioning of the land.

There is widespread agreement that the health of vegetation, soils and waterways in many parts of the Australian landscape have become seriously impaired, resulting in reduced resilience in the face of increasingly challenging climate variability.

Agriculture is the sector most strongly impacted by these changes. It is also the sector with the greatest potential for fundamental redesign. The Australian nation has the opportunity to be a world leader in the implementation of innovative technologies centred on adaptation to our variable climate.

In addition to enabling the farming community to more effectively deal with warmer, drier conditions, the restoration of landscape function will result in the active drawdown of excess CO_2 from the atmosphere via stable biosequestration in soils.

Fundamental redesign of food, fuel and fertiliser production is vital to the survival and profitability of the Australian agricultural sector. We cannot afford to continue with business as usual.

While climate cannot be altered, the resilience of the agricultural sector can be markedly improved by changes to land management regimes. The most meaningful indicator for the health of the land, and the long-term wealth of a nation, is whether soil is being formed or lost. If soil is being lost, so too is the economic and ecological foundation on which production and conservation are based.

Completing the Carbon Cycle

Carbon is the basic building block for life. It is only a pollutant when in excess in the atmosphere or dissolved in water. Over millennia a highly effective carbon cycle has evolved to capture, store, transfer, release and recapture biochemical energy in the form of carbon compounds. The health of the soil - and therefore the vitality of plants, animals and

Holistically grazed land (left) compared to set-stocked neighbor's paddock (right), southern Victoria, Australia, April 2009. There has been no fertilizer used on the holistically grazed property for nine years. (Photo by Patrick Francis) people, depends of the effective functioning of this cycle.

All major greenhouse gases, including carbon dioxide, are cyclical. The issue is that too much CO_2 is being emitted to the atmosphere and insufficient amounts are being sequestered. A 'carbon pollution reduction' agenda might therefore include:

(1) 'completing the carbon cycle' through active biosequestration of emitted CO_2 into soils, the planet's largest carbon sink, with a capacity five times greater than that of vegetation; and

(2) developing regional biofuel and biofertiliser capacity, reducing dependence on fossil fuels in the agricultural sector.

Emissions trading, while useful to focus public and corporate attention on the need to reduce carbon pollution, cannot of itself have significant impact on global concentrations of atmospheric CO_2. It could however, be beneficial, if the funds raised were used to restore balance to the climate by supporting natural carbon, nitrogen and water cycles, via the restoration of perennial groundcover and soil microbial activity. Economic development is only sustainable if it strengthens, rather than depletes, natural resources.

Recent research has confirmed that the capacity of the ocean to act as a carbon sink has markedly declined, with the top 100 metres of water being close to CO_2 saturation. This finding highlights the urgent need for 'active drawdown' of excess CO_2 already in the atmosphere, as well as reducing further emissions.

The well grassed area on the left has good infiltration compared to the overgrazed area on the right, which has lost soil carbon and soil water-holding capacity. Rainfall that cannot infiltrate simply sits on top of the ground and evaporates. (Photo by Patrick Francis)

The dark coloured carbon sequestered around the roots of perennial grasses is readily observed in light coloured soils. (Photo by Christine Jones)

The Soil Carbon Sink

Biosequestration in soil offers a practical and almost immediate solution to legacy load CO_2.

Managing agricultural soils to enhance their capacity to sequester and store large volumes of atmospheric CO_2 in the form of stable humus also has significant implications for soil structure, water-holding capacity and nutrient status. These factors strongly influence resilience, productivity and profitability on-farm, with flow-on benefits for local communities, landscape function, human health and regional and national economies.

Over 95% of terrestrial diversity is in the soil. In order for this life to flourish, the soil ecosystem requires fuel in the form of carbon (from green plants) and 'habitat' in the form of high root biomass. Further, the soil surface requires year-round protection from erosion and temperature extremes (both highs and lows).

Periodically bare soils generally contain only half the organic carbon of similar soils in the same region under perennial cover (for example, see table below). As a result they have poorer structure, lower soil water-holding capacity and reduced nutrient levels.

The data in the below table indicate that a change from annual groundcover (soil bare in summer) to perennial groundcover (healthy living soils all year round), has the potential to increase soil carbon levels by around 1% in low rainfall regions and up to 3% in higher rainfall regions.

An increase of 1% in the level of soil carbon in the 0-30cm soil profile equates to sequestration of 154 tons of CO_2 per hectare (tCO_2/ha) if an average bulk density of 1.4 g/cm^3 is assumed, while an increase of 3% in the level of soil carbon equates to sequestration of 462 tCO_2/ha.

Innovative (frontier-type) land management technologies that promote soil building are more productive and less expensive than conventional farming practices that deplete soil carbon.

When biologically friendly fertilisers and continuous sequestration (via perennial cover) are used in place of conventional fossil-fuel based fertilisers in traditional bare fallow systems, the carbon footprint is reversed (that is, more carbon is sequestered than emitted).

Irrespective of whether global temperatures increase, decrease or stay the same, the implementation of a national policy for soil carbon restoration utilising funds derived from the Federal Government's Carbon Pollution Reduction Scheme would build 'real' wealth and ensure security of food and fresh water for the Australian nation.

Farming and Health

The best national health policy is good agricultural policy.

The key purpose of farming is — or should be — to produce nutritious food that benefits the health and well-being of the population. In reality, the farming sector sits at the centre of a complex, capital intensive supply chain focussed largely on production. Decisions are based on the cost of inputs and the anticipated value of outputs. Rarely is the nutritional value of the product considered. The health dimension has tended be viewed as a technical problem that can be fixed by an endless variety of pharmacological magic bullets — accompanied by seemingly limitless unpleasant side effects.

Low, normal and high ranges for average soil organic carbon levels (% by weight) in crop and pasture soils in low rainfall (< 500mm) and high rainfall (> 500mm) regions, Victoria.

	Low rainfall (<500 mm)		High rainfall (> 500 mm)	
	Crop	**Pasture**	**Crop**	**Pasture**
Low	0.9	1.7	1.45	<2.9
Normal	0.9 - 1.4	1.7 - 2.6	1.45 - 2.9	2.9 - 5.8
High	>1.45	>2.6	>2.9	>5.8

Source: Brown , A.J., Fung, K.K.H. and K.I. Peverill (1980). *A manual on the soil testing service provided by the Division of Agricultural Chemistry*. Technical Report Series - Victorian Department of Agriculture, no 34, 16 p.

Interestingly, when people are asked which factors are of greatest importance to them personally, good health nearly always tops the list. Contrary to popular belief, good health is not determined by the quality of our medical system. Rather, it is closely linked to the nutrient content of food - which in turn is linked to the ecological health and organic carbon content of the soil in which food is grown.

Soil health and human health are more deeply connected than many people realise. Food is often viewed in terms of quantity available, hence 'food scarcity' is not seen as an issue in Australia. However, food produced from depleted soils does not contain the essential trace minerals required for the effective functioning of our immune systems.

The nutritional status of soils, plants, animals and people has fallen dramatically in the last 50 years, due to losses in soil carbon, the key driver for soil nutrient cycles. Soil carbon levels in turn are linked to the quality of groundcover.

Routine premature deaths by degenerative conditions such as cardiovascular disease and cancer have become prominent when they were once relatively uncommon. The cancer rate, for example, has increased from approximately 1 in 100, fifty years ago, to almost 1 in 2 today. The effectiveness of the human immune system has been severely compromised by increased exposure to more and more chemicals coupled with insufficient mineral density in food.

This situation can be dramatically improved by the integration of perennial groundcover and biology friendly fertilisers into agricultural production systems, reducing the need for chemical inputs and increasing the nutritive value of the food produced.

Livestock and Methane

Wetlands, rivers, oceans, lakes, plants, decaying vegetation (especially in moist environments such as rainforests) — and a wide variety of creatures great and small — including termites, camels, bison, bison, antelopes, reindeer, caribou and giraffes, have been producing methane for millions of years. A clear distinction needs to be made between natural methane from ruminants and man-made methane from industrial sources. For example, a medium-sized whale produces methane emissions equivalent to 40 cows. There are international policies in place to protect whales and other methane producing wildlife, as well as protecting and enhancing methane-producing ecosystems such as wetlands and rainforests. The natural methane produced in the rumen of pasture fed livestock is not man-made — and is not increasing.

The largest single source of methane worldwide is wetlands (22%), followed by coal, oil and natural gas (19%), enteric fermentation (16%), rice cultivation (12%), with burning, landfill, sewage, manure, termites and release from the ocean making up the remaining 31%.

Global atmospheric levels of methane have remained relatively constant over the last ten years, despite increased ruminant numbers worldwide. This finding raises questions about the relative contribution of ruminant livestock to global methane levels and suggests that other sources and sinks may be playing a more significant role. Methane is broken down in the atmosphere within seven years by the free radical hydroxyl (OH), which is a naturally occurring process. This atmospheric cleanser has been shown to adjust itself up and down periodically and is believed to account for the stability in methane levels in the earth's atmosphere over the last decade – that is, until a sudden increase in 2008.

A global study published in *Geophysical Research Letters* in October 2008 reported that the first increase in methane levels this century had been recorded in the last 12 months. This increase is thought to be due to rapidly accelerating methane hydrate emissions from the Arctic seabed. The findings from the Arctic research cast doubt on the value of attempting to suppress methane production from ruminants.

In Australia, ongoing dry conditions in many regions have resulted in falling stock numbers. Over the last two decades, livestock sources of methane have not increased in this country.

There is therefore no factual basis for selectively targeting ruminants for a 'methane tax' – or worse, interfering with this natural process. Why not a 'carbon pollution tax' on people, cats, dogs, horses, chickens, pigs — and marsupials — for all the CO_2 collectively expired into the atmosphere? Or perhaps a 'water

Vertical stacking. Oats sown into perennial native pasture yield grain plus grazing from the same piece of land. (Photo by Sarah Bruce)

Cropped paddock showing the summer-green perennial pasture beneath a harvested strip of winter oats, sown between alleys of tagasaste. (Photo by Tim Wiley)

vapour tax' on all living creatures? Water vapour is the greenhouse gas that has increased to the greatest extent since the industrial revolution, accounting for 95% (by volume) of increased radiative forcing. Imposing penalties on people and animals for natural processes such as exhaling CO_2 and water vapour makes as much sense as imposing a methane tax on livestock.

In appropriately managed rotationally grazed perennial grasslands and shrublands, green plants and the soil ecosystem 'complete the carbon cycle', ensuring more carbon is sequestered than emitted, easily compensating for the methane produced by livestock. It is interesting therefore, than none of the $26.8 million in Australian taxpayers money recently allocated to methane research included this aspect.

A complete life-cycle analysis would reveal that when the carbon footprint of fuel, fertiliser, herbicides and pesticides are factored in, plus erosion, water-quality decline and the carbon dioxide and nitrous oxide losses from soil, conventionally produced soybeans (or other sources of non-animal protein) would be less environmentally friendly than well-managed livestock grazing. Indeed, the fastest and most economical way to restore soils that have been degraded by annual cropping is through the use of rotationally grazed perennial pastures.

When the ecosystem services of clean air and clean water are taken into consideration, it becomes obvious that perennial groundcover provides benefits for all sectors of society, including urban dwellers. The sooner the completely illogical 'eat vegan' and 'natural methane is a problem' issues are resolved, the better. The evolution of the rumen as an efficient way of digesting plant material evolved around 90 million years ago. It seems extraordinarily inappropriate to interfere with this natural process.

Perennial groundcover, the biomass it produces and the livestock it feeds are all extremely beneficial (if not fundamental) to the planet, provided they are appropriately managed.

Mycorrhizal Fungi

Soil benefits in many ways from the presence of living plants year-round, due to reduced erosion, buffered temperatures, enhanced infiltration and markedly improved habitat for soil biota. Significantly, it is the photosynthetic capacity of living plants (rather than the amount of dead biomass added to soil) that is the main driver for soil carbon accumulation.

Mycorrhizal fungi differ quite significantly from decomposer type microbes in that they acquire their energy in a liquid form, as soluble carbon directly from actively growing plant roots. By this process they are actively drawing down atmospheric carbon and turning it into humus, often quite deep in the soil profile, where it is protected from oxidation.

Where mycorrhizae are functioning efficiently, 40-60% of the carbon fixed in green leaves can be channelled directly into soil as soluble carbon, where it is rapidly polymerised with minerals and nitrogen and converted to stable humic compounds in the soil food-web. The humates formed by soil biota are high molecular weight gel-like substances that hold between four and twenty times their own weight in water. Humic substances significantly improve soil structure, porosity, cation exchange capacity and plant growth.

Mycorrhizal fungi access and transport nutrients such as phosphorus, zinc and nitrogen in exchange for carbon from their living host. Plant growth is usually higher in the presence of mycorrhizal fungi than in their absence. In perennial grasslands, mycorrhizal fungi form extended networks that take several years to develop. They have mechanisms that enable them to survive while host plants are dormant but cannot survive if host plants are completely removed from the ecosystem.

Under appropriately managed perennial groundcover, soil water balance is improved by hydraulic lift and hydraulic redistribution in seasonally dry environments. These processes bring moisture to the root-zone that would not be available to an annual crop or pasture.

Broadacre cropping could benefit enormously from widely spaced rows or clumps of long-lived perennial grasses and fodder shrubs. As yet we do not know the required critical mass to restore soil ecosystem function, but it might only need to be 5-10% perennial cover. The benefit of permanent mycelial networks in terms of aggregate stability, porosity, improved soil water holding capacity, reduced erosivity and enhanced nutrient availability would be immense.

Where soil carbon is mycorrhizal in origin it is stable, which is vitally important in the current debate about soil carbon losses during droughts and fires. The stabilising humification process can also be enhanced via additions of certain humic materials (often included in biology-friendly fertilisers), which have a protective effect on soluble carbon exuded by plant roots.

Conclusion

The number of farmers in Australia has fallen 30 per cent in the last 20 years, with more than 10,000 farming families leaving the agricultural sector in the last five years alone. This decline is ongoing. There is also a reluctance on the part of young people to return to the land, indicative of the poor image and low income-earning potential of current farming practices.

The longer we delay undertaking changes to land management, the more soil (and soil carbon and soil water) will be lost, exposing an increasingly fragile agricultural sector to escalating production risks, rising input costs and vulnerability to climatic extremes.

It's time to move away from depletion-style, high emission, chemically based industrial agriculture and get serious about grass-roots biologically based alternatives.

The future of Australia depends on the future of our soil - and our willingness to look after it.

Dr. Christine Jones is an internationally renowned and highly respected groundcover and soils ecologist. She has a wealth of experience working with innovative landholders to implement regenerative land management techniques that enhance biodiversity, increase biological activity, sequester carbon, activate soil nutrient cycles, restore water balance, improve productivity and create new topsoil. Contact Dr. Jones at christinejones22@aol.com, *and visit her website:* www.amazingcarbon.com. *Dr. Jones will be speaking at The Quivira Coalition's 2010 Annual Conference this November.*