Our soils, our future

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Introduction

There has been a notable 'climate shift' in many of the arable regions of eastern, southern and western Australia. A trend to less reliable autumn, winter and spring rainfall has increased production risks for annual cereal crops, while the greater incidence of episodic high intensity rainfall events in summer has heightened the vulnerability of bare fallows to erosion. Declining rainfall experienced over the last 7-10 years has severely impacted on the financial viability of cropping and grazing enterprises and disrupted the social fabric of rural communities.

These events have highlighted a fundamental lack of resilience in current agricultural production systems.

Historical losses of soil and soil carbon

In little over 200 years of European settlement, more than 70 percent of Australian agricultural land has become seriously degraded. Despite efforts to implement 'best practice' in soil conservation, the situation continues to deteriorate.

On average, 7 tonnes of topsoil is lost for every tonne of grain produced. This situation has worsened in recent years due to an increased incidence of erosion on unprotected topsoils, coupled with declining yields.

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.

In addition to the loss of soil itself, there has been a reduction of between 50% and 80% in the organic carbon content of surface soils in Australia since European settlement (2, 3, 4, 11, 12).

Losses of carbon of this magnitude have immeasurable economic and environmental implications. Soil carbon is the prime determinant of agricultural productivity, landscape function and water quality.

Further, the carbon and water cycles are inextricably linked. Humus holds approximately four times its own weight in water (8). The most beneficial adaptation strategy for climate change would therefore be one that focuses on increasing the levels of both carbon and water in soils.

Discussions on adapting to climate change are irrelevant unless they focus on rebuilding healthy topsoil.

Building new topsoil

Healthy groundcover, active root growth and high levels of microbial association (7), are fundamental to the success of any endeavour to build new topsoil. These factors are absent from conventionally managed broadacre cropland.

Current 'best practice', that is, chemically-based zero-till broadacre cropping (Fig.1) does not provide a suitable environment for high levels of biological nitrogen fixing, nutrient cycling, hydraulic redistribution, active sequestration of humified soil carbon, or soil building.

Fig.1. *Current 'best practice'. Chemically based zero-till farming lacks essential requirements for biological N-fixing, sequestration of humified soil carbon and building of new topsoil.*

Fortunately, the highly effective land management technique of 'perennial cover cropping' (Figs. 2, 3 and 4) has become more widely adopted in recent years. This practice involves the direct drilling of annual grain or fodder crops into 'out-of-phase' dormant perennial groundcover.

Fig.2. *The 'new face of agriculture'. Annual grain crop direct-drilled without herbicide into dormant perennial groundcover enhances plant-microbial associations, vastly improves rates of biological N fixation, stimulates nutrient cycling, facilitates sequestration of highly stable, humified soil carbon and promotes formation of new topsoil. (Photo: Scott and Jo McCalman, 'Jedburgh' Warren)*

The essential first step to rebuilding topsoil is to maximise photosynthetic capacity. A permanent cover of perennial plants provides an ongoing source of soluble carbon for the soil ecosystem, buffers soil temperatures, inhibits weeds, reduces erosion, improves porosity, enhances aggregate stability and water infiltration, slows evaporation and 'conditions' the soil for the production of healthy, high quality, over-sown annual crops.

The soluble carbon exuded into the rhizosphere by perennial groundcover plants and/or transported deep into soil by mycorrhizal fungi, provides energy for the vast array of microbes and soil invertebrates that produce sticky substances enabling soil particles to be glued together into lumps (aggregates). When soil is well aggregated, the spaces (pores) between the aggregates allow the soil to breathe, as well as absorb moisture quickly when it rains. A healthy topsoil should be 'more space than stuff', that is, less than 50% solid materials and more than 50% spaces.

Friable, porous topsoils make it easier for plant roots to grow and for small soil invertebrates to move around. Well-structured soils retain the moisture necessary for microbial activity, nutrient cycling and vigorous plant growth and are less prone to erosion. Soil structure is very fragile and soil aggregates are continually being broken down. An ongoing supply of energy in the form of carbon from the rhizosphere exudates of actively growing plants and, to a lesser extent, decomposing organic materials, enables soil organisms to flourish and produce adequate amounts of the sticky secretions required to maintain soil structure and function.

Healthy, chemical-free soils also create appropriate conditions for humification (conversion of soluble carbon to humus), a process which does not occur in most conventionally managed agricultural soils.

***Fig. 3**. Modern machinery is well suited to sowing annual grain crops into dormant perennial groundcover, a technique known as perennial cover cropping. (Photo: Scott and Jo McCalman, 'Jedburgh' Warren)*

Cropping into dormant perennial groundcover is a one-pass operation that markedly reduces fuel costs and largely eliminates the need for fossil-fuel based herbicides, fungicides and pesticides. Perennial cover cropping has many similarities to annual cover cropping, but brings with it the ecosystem benefits of perennial groundcover. The practice of perennial cover cropping was inspired by the highly innovative integrated cropping and grazing technique of 'pasture cropping' initiated by Darryl Cluff over a decade ago and further developed by Colin Seis (1, 5, 6).

The use of 'biology friendly' fertilisers, particularly those based on humic substances, in combination with Yearlong Green Farming (YGF) techniques such as perennial cover cropping, can have a protective effect on soil carbon, slowing or preventing its decomposition and further reducing the carbon footprint of agriculture.

There is no valid reason for the Australian agricultural sector to be a net emitter of CO_2,

The world's soils hold three times as much carbon as the atmosphere and over four times as much carbon as the vegetation. With 82% of terrestrial carbon in soil (compared to only 18% in vegetation), soil represents the largest carbon sink over which we have control. Soil is also the world's largest store of terrestrial diversity, with over 95% of life forms being underground (that is, only 5% of biodiversity is above ground).

Sequestering humified carbon in soils represents a practical, permanent and productive solution to removing excess CO_2 from the atmosphere. By adopting regenerative soil-building practices, it is practical, possible and profitable for broadacre cropping and grazing enterprises to record a net sequestration of carbon in the order of 25 tonnes of CO_2 per tonne of product sold (after emissions accounted for).

Australia's annual emissions of CO_2 are predicted to reach 603 million tonnes in 2008.

There are therefore 603 million good reasons for agriculture to be a net sequester of CO_2

It would require only a 0.5% increase in soil carbon on 2% of agricultural land to sequester all Australia's emissions of carbon dioxide[1]. That is, the annual emissions from all industrial, urban and transport sources could be sequestered in farmland soils if incentive was provided to landholders for this to happen.

This would provide Australia with a 50 year 'window of opportunity' to be carbon neutral while implementing viable technology to meet future energy needs.

Australian Soil Carbon Accreditation Scheme (ASCAS)

Dr Christine Jones launched the Australian Soil Carbon Accreditation Scheme (ASCAS) in March 2007. ASCAS is a stand-alone incentive scheme with voluntary involvement, which encourages the adoption of innovative soil building practices (9). Widespread implementation of techniques developed by leading-edge landholders (as depicted in Figs. 2, 3 and 4) will transform the agricultural sector. Adoption of these processes needs to be fast-tracked.

ASCAS is the first incentive payments scheme for soil carbon in the Southern Hemisphere, placing Australia among world leaders in the recognition of soil as a verifiable carbon sink.

Incentive payments for annual measured increases in soil carbon above baseline levels have been sourced from a private donation by Rhonda Willson, Executive Chairman, John While Springs (S) Pte Ltd, Singapore. Receipt of Soil Carbon Incentive Payments (SCIPs) is similar to being paid 'on delivery' for livestock or grain, with the bonus being that sequestered carbon

[1] A 0.5% increase in soil carbon across only 2% of agricultural land would sequester 685 million tonnes CO_2, well above the country's annual emissions. (Assumptions: 0-30cm soil profile, bulk density 1.4 g/cm^3, land area 2% of 445 million hectares).

remains in soil, conferring multiple landscape health and productivity advantages. Soil Carbon Incentive Payments are calculated at one-hundredth the 100-year rate ($25/tonne CO_2-e).

Annual payments to landholders based on measured soil parameters provide incentive for maximising soil carbon sequestration and maintaining permanency of sinks.

The amount of humified carbon in soil is directly related to nutrient bio-availability, soil structural stability, soil water-holding capacity, agricultural productivity and landscape function. One of the aims of the ASCAS project is to collect data that will enable rigorous scientific evaluation of soil carbon, water, nutrients and crop yield under regenerative regimes.

Adapting to climate change

There is an urgent need for Australian agricultural industries to adapt to climate change. To be effective, the strategies employed will require radical departures from 'business as usual'.

It is possible that global warming could accelerate even more rapidly than observed to date. Fundamental redesign of agricultural production systems will enable the sequestration of more carbon and nitrogen than is being emitted, as well as enhancing soil water retention, improving the resilience of the resource base and restoring richness to farmed soils. These much-needed changes will assist the agricultural sector to deal confidently with a changing climate

Rather than increase costs, mitigation of climate change via the adoption of regenerative soil building practices would bring net financial benefits to landholders and rural communities (the sectors hardest hit by climate change).

Fig 4. Emerging wheat crop one month after sowing into dormant perennial pasture. Large volumes of soluble carbon are fixed in green leaves during photosynthesis, transferred to roots and thence to soils via the hyphae of mycorrhizal fungi. After grain harvest, the warm-season native perennial pasture will activate and continue the sequestration process, building soil carbon over the summer period. (Photo: Scott and Jo McCalman, 'Jedburgh', Warren)

Yearlong Green Farming (YGF) techniques such as perennial cover cropping rapidly build humified soil carbon, improving the capacity of soil to hold water and increasing the resilience of farming systems to climatic extremes.

Farming in a perennial base

A change to farming in a perennial base has many advantages, including

- same or better yield than chemical fallow or cultivation-style farming
- fewer inputs, resulting in higher gross margins per hectare
- less reliance on fossil fuel-based fertilisers and farm chemicals
- enhancement of natural soil building processes
- 'reverse' carbon footprint - more carbon sequestered than emitted
- 'reverse' nitrogen footprint - more nitrogen fixed then emitted
- increased water use efficiency due to lower evaporative demand
- improved soil water balance due to hydraulic lift and hydraulic redistribution
- no bare soil for weeds to grow - paddocks virtually weed-free
- reduced financial risk - no expenditure if a crop is not sown
- additional income stream from harvest and sale of perennial grass seed
- more time for family - little or no requirement for cultivation or herbicide application
- higher biodiversity of plants and animals (eg bettongs returning on some farms)
- incentive for all members of the farm family, including children, to become involved

The new face of agriculture

Widespread adoption of productive and resilient agricultural practices that enhance net sinks for atmospheric carbon would have a revitalising effect on the natural resource base and provide a financial benefit to government, individuals and rural and regional communities.

Furthermore, farming in a perennial base would enhance the resilience of the agricultural landscape to a wide range of climatic extremes, some of which may not even have been encountered to date.

The development of an appropriate incentives framework for regenerative agricultural activities would reverse the farm sector's carbon and nitrogen footprints (more C and N sequestered than emitted) and improve food security in a warming, drying environment.

An overview of the Australian Soil Carbon Accreditation Scheme (ASCAS) has been provided as an example of an incentive-based (rather than regulatory) approach. The ASCAS project is an initiative designed to provide proof of concept that: -

- innovative soil management practices exist for sequestering soil carbon
- improvements in soil carbon and soil health can be measured
- landholders can be financially rewarded for building soil carbon

The ASCAS project supports soil restoration by providing financial incentive for landholders to move away from 'business as usual' (that is, carbon depleting activities) and by improving community knowledge on effective methods for building soil carbon.

Irrespective of climate change, it would be of enormous economic benefit to the agricultural sector to rebuild soils by implementing practices that increase levels of humified soil carbon and reduce reliance on fossil fuels.

In 1937, Franklin Roosevelt (10) stated *"The nation that destroys its soil destroys itself"*

The future of Australia depends on the future of our soil.

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