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HOUSE OF REPRESENTATIVES STANDING COMMITTEE
ON
PRIMARY INDUSTRIES AND RESOURCES

INQUIRY INTO AUSTRALIAN FARMERS AND CLIMATE CHANGE

BY

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IGNITE ENERGY RESOURCES PTY LTD

3 SEPTEMBER 2009

Biological Carbon Capture & Storage (Bio-CCS) Demonstration Projects

The Federal, State and Local Governments in Australia, and big emitters, should implement bio-sequestration of atmospheric CO_2, via soil carbon, et al, in rural lands, as a means of offsetting fossil fuel emissions in Australia, at very low cost.

CSIRO have now confirmed the biosequestration possibilities in the rural landscape – in the August 2009 CSIRO 'National Research FLAGSHIPS' report on 'Sustainable Agriculture' – 'An Analysis of Greenhouse Gas Mitigation and Carbon Biosequestration Opportunities from Rural Land Use' - which resulted from a request made through the Queensland Government (see attached).

This CSIRO report confirmed that Queensland could 'attain' 77% reduction of its annual greenhouse gas emissions (being 140 Mt CO_2e/yr) through change in rural land use and management, in particular via the cropping and rangelands (not including change of land use, such as crop/pasture to trees). The report notes a technical potential of 293 Mt CO_2e/yr abatement from terrestrial GHG management, in Queensland, for the next 40-50 years (after which saturation of soil carbon may reduce sequestration).

This sort of potential (scaled accordingly) exists for all States, using a range of Biological Farming/Fertilisation Systems (BFS) and Grazing Management systems, et al (including biosequestration of CO_2 emissions from fossil fuel power plants via algae to biofuel and animal feed/fertiliser material), to provide a so-called 'Carbon Bridge' - to offset Australia's total fossil fuel emissions until 'cleaner coal' (geological carbon capture and storage – Geo-CCS) and/or renewable and low emissions power generation investments can be achieved, economically.

The Australian Governments and Business should establish three 'International Biosequestration - Carbon Capture and Storage (Bio-CCS) Demonstration Projects' (in WA, SE Australia and NE Australia), with the support of the Clinton Foundation and the UN, alongside the 'Geological CCS Demonstration Project' in the Bass Strait, and monitored by CSIRO. (A Victorian/SA based Project is particularly appropriate as Gippsland lignite (brown coal) is ideally suited for the manufacture of Biological Fertiliser based on the high humic/fulvic content of some of the deposits.)

Such Bio-CCS projects can deliver the required GHG reduction needed by Australia by 2020 and through to 2050, as a transitional process to the subsequent implementation of Geo-CCS and low emissions power generation in the post 2020 to 2030 timeframe.

Under any scenario, Geo-CCS is not expected to be contributing significantly to GHG reductions before the 2020, more likely 2030 to 2040, timeframe.

In this context it is recommended that the Global CCS Institute also embrace Bio-CCS along with Geo-CCS, as part of the National and International GHG reduction solution. Many large Australian GHG emitting companies are very interested in such Bio-CCS Demonstration Projects - that can deliver them low cost, certain carbon credits/offsets - to insulate their businesses and employment from the future shocks of carbon pricing in the 'market'.

These Bio-CCS Demonstration Projects will prove internationally important, Australian developed techniques/systems to reduce legacy CO_2, and offset the emissions from current economically essential industry. The knowledge and systems will be applicable and exportable to countries/continents like China, India, Africa, Middle East and the Americas, as a global solution for the next half century to enable safe transition to low emissions energy sources.

Note: Two further papers by CSIRO are relevant:

- The CSIRO paper (attached), from 1997, recommends that "There is considerable potential to sequester carbon into agricultural soils in Australia and it is suggested that Australia should argue for their inclusion in the allowable sources and sinks." (Estimates of soil carbon depletion/sequestration-opportunity are very low and have been upgraded by orders of magnitude in subsequent science papers)
- The second CSIRO document (attached) announces "A new simple, fast and inexpensive technique for measuring carbon in soils"

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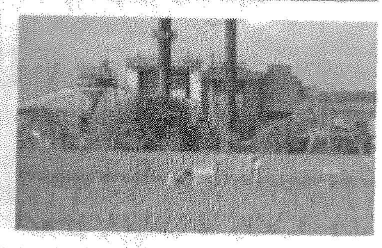

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An Analysis of Greenhouse Gas Mitigation and Carbon Biosequestration Opportunities from Rural Land Use

August 2009

Executive summary

This CSIRO report provides an in-depth assessment of the greenhouse gas (GHG) sequestration/mitigation potential likely to be achieved through change in rural land use and management, based on a review of current knowledge and consultation with a cross-section of scientists and land management experts. The focus is on Queensland but in most instances national potential is also estimated.

The report revisits the Garnaut Review (2008) estimates[1] for terrestrial greenhouse gas sequestration – in more detail, with a discussion of implementation issues, risks and interactions between options. The review was requested by the Queensland Premier's Council on Climate Change – as a technical input to policy development. The report confirms that there are a wide variety of options for sequestering or mitigating GHG emissions through changed land use and management: the options studied were based on the Garnaut Review categories with some changes in definition and emphasis.

This report demonstrates that Australia has the opportunity to offset a significant proportion of our GHG emissions, by storing carbon in the landscape and changing the emissions profile from rural land use. Thus, the broad thrust of the Garnaut Review is supported – within Queensland an overall **technical potential** of 293Mt CO_2-e/yr for GHG abatement was estimated, with 140 Mt of this potential being assessed as **attainable** with concerted efforts in technical and management changes, policy adjustment and shifts in current land management priorities. It must be recognised that these estimates contain a combination of biological, technical and implementation uncertainty.

In 2007, total GHG emissions for Queensland were 182 Mt CO_2-e/yr, so the attainable estimate of 140 Mt CO_2-e/yr (77% of the state's emissions) indicates that terrestrial GHG management could play a key role in emissions abatement over the next 40-50 years. A complete set of national estimates was not undertaken but where they were available the results suggest a similar outcome would be achieved.

For Queensland, the largest quantities of abatement are associated with options that cover forestry activities such as carbon forestry (including biodiversity plantings), commercial forest plantations, and reduced land clearing/managed regeneration. Estimates are that these options may account for approximately 105 Mt CO_2-e/yr, and importantly have relatively low barriers to implementation.

Across many of the other studied options, it is clear that enabling technology and appropriate policy incentives could lead to a significant reduction in emissions or increased carbon sequestration. Changes in agricultural practices to build carbon reserves in agricultural and rangelands systems could yield 26 Mt CO_2-e/yr while substitution of fossil fuels with renewable bioenergy could reduce emissions by 9 Mt CO_2-e/yr.

Many of these options are most effective over the next 40–50 years as increased levels of saturation over time will reduce returns on investment in sequestration. Nevertheless, they offer a key component of GHG management within a framework of more comprehensive abatement policies and practices, especially in the near term. Although carbon storage in landscapes will saturate, the production of renewable biomass feedstock for biochar and bioenergy provides the potential for continued mitigation post 2050. However, an integrated approach to GHG abatement across agriculture, energy and transport sectors is still important; sequestration has large natural uncertainties compared to achieving similar abatement through a reduction in the burning of fossil fuels.

There were significant differences to the Garnaut estimates for individual abatement options; in most cases these were due to definitional differences but they also occurred because the study brought in more recent analyses and models. These differences are discussed in the report. In this study, as with the Garnaut Report, estimates for soil carbon storage were only made for cropping systems and rehabilitation of rangelands. Soil carbon changes associated with enterprise change (crop to pasture, pasture to trees) were not considered. Although major additional soil carbon storage could theoretically be achieved by such land use change, the potential rates of storage and areas of land are difficult to define with the current state of knowledge.

1 Garnaut, R (2008) The Garnaut Climate Change Review: Final Report, Cambridge University Press, Port Melbourne. http://www.garnautreview.org.au/index.htm) – ch.22

The report discusses each option in detail – this allows an evaluation of the scope of the option, the level of uncertainty, risks and barriers to implementation and the current status in GHG accounting. Also discussed in the report are the investment and management actions required for implementation, the relative feasibility and attractiveness, the regional applicability of different options and the economic, social and institutional issues associated with land use change. However, the report does not quantify the relative cost effectiveness of the different mitigation and sequestration opportunities.

The analysis found that forestry options are likely to be the easiest to implement given the current level of technical knowledge and certainty about levels of carbon storage. The most difficult to implement are the options that apply to complex eco-systems and where there is a high level of uncertainty about carbon storage, for example, regeneration of rangelands and mulga.

International and national policy frameworks will also influence implementation. Some options such as carbon forestry are covered in a clear manner in the Kyoto Protocol and the proposed Carbon Pollution Reduction Scheme (CPRS), while other options, where carbon is stored in the soil or in regenerated native vegetation, are not readily accommodated in the current frameworks in a manner that best suits the Australian environment.

The goal of this report was to better quantify the magnitude of sequestration/mitigation opportunities so that on-going policy development can be undertaken with knowledge of the likely quantum of GHG abatement offered by land use change.

Despite the initial focus on Queensland policy needs, the published document has broader relevance to national carbon emissions reduction strategies. Of Australia's total emissions in 2007 (597 Mt CO_2-e) some 88 Mt came from agriculture and 77 Mt from deforestation, including land clearing for agriculture. Thus abatement through rural land use change is valuable despite the current uncertainty around estimated values and complications with the inclusion in international GHG accounting frameworks. This report provides underpinning information on the nature of these options and points to the key literature. It provides an important basis for national discussions on the potential for terrestrial GHG sequestration and the dimensions involved in its pursuit.

The options studied in the report are detailed in the **Summary Table** on page 12. Many options overlap – an investment or development of one option will limit the potential for development of others. This overlap has been identified, where possible, and overall figures adjusted to account for competition for resources for GHG abatement.

The report seeks to extend the analysis beyond the technical potential identified in the Garnaut Review to include concepts of what is attainable given concerted efforts in technical and management changes, policy adjustment and shifts in current land management priorities. The options for sequestration/mitigation are qualitatively different so a consistent quantitative estimate of attainable levels was not applied across options. In each case the assessment contained a combination of biological, technical and implementation uncertainty. An economic dimension is clearly part of this assessment but was only explicitly applied in some options. For example, it was assumed that the price for carbon would largely influence land use change to carbon forestry and this option was modelled with a carbon price of $20/tonne, whereas the attainable level of mitigation for livestock was assumed to be largely a function of the availability of appropriate technology.

Much of the terrestrial sequestration potential involves spatially extensive activities, where small contributions per unit land area collectively contribute significantly through application over large areas. This extent means that their widespread adoption, as might occur by their inclusion in the proposed CPRS and a high carbon price, could see them transform rural landscapes with substantial benefits; alternatively adverse outcomes for the environment, productive capacity, rural livelihoods and commodity supplies are possible without a planned and systemic approach to implementation. These cross-cutting issues are identified in the document and discussed. To achieve the levels of GHG abatement assessed as attainable in this report would require changes in policy and economic settings and in the technical toolkit. Some change will be possible within Queensland, some will require adjustment to national settings and some are dependent on international developments, especially in the carbon accounting framework for post-Kyoto climate agreements.

Agricultural Soils as Potential Sinks for Carbon

Roger Swift and Jan Skjemstad, CSIRO Land and Water

for the CSIRO Biosphere Working Group

Summary

The amount of carbon lost from agricultural soils in Australia since European settlement is estimated to be around 1050 Mt C, comprising 600 Mt C from more intensively managed, periodically cultivated soils and 450 Mt C from the large areas of extensively managed grazing lands. These figure also represents the theoretical potential for the amount of carbon that could be sequestered by these soils through changes in agricultural practices. In practical terms it is likely that only a fraction of this potential is ever likely to be realised. Rebuilding soil carbon levels is a slow process which imposes limits on what can be achieved by 2010. Even so, it is suggested that a sequestration rate in the order of about 2 Mt C pa is within the realms of possibility and that the sequestration by agricultural soils can make a significant contribution to the achievement of Australia's greenhouse gas emissions targets.

On this basis it is recommended that Australia should argue for the inclusion of agricultural soils in the allowable sinks and sources.

Introduction

The Kyoto Protocol makes provision for the next session of the Conference of Parties to address the issue "*as to how and which additional human-induced activities related to changes in greenhouse gas emissions and removals in* ***agricultural soils*** *and land use change and forestry categories, shall be added to, or subtracted from*" the sources and sinks allowable to meet GHG emission targets.

From an Australian point of view we need to assess the potential for our agricultural soils to sequester carbon and, based on this information, whether or not Australia should be seeking inclusion of agricultural soils in the inventory.

Soil Carbon Losses

To assess the potential for Australian agricultural soils to sequester carbon, it is necessary in the first instance to make an estimate of the amount of carbon that has been lost from these soils. In common with other cultivated soils around the world, agricultural soils in Australia have lost a substantial amount of carbon following the introduction of more intensive crop production systems involving a range of soil tillage practices and other exploitative systems. About 6 per cent of the land area (about 50 M ha) has been used for this type of agriculture. Much larger areas, including the estimated 450 M ha of rangelands, have been used for extensive grazing.

To estimate the loss of carbon from the 50 M ha of periodically cultivated soils, a similar approach has been used to that taken by Russell and Williams (1982) except it is assumed that:

these soils contained on average 40 t C per ha to a depth of 30 cm (a relatively conservative figure) in their virgin state

30 per cent of this carbon has been lost as a result of prolonged agricultural use.

For the large areas of other agricultural soils, mainly rangelands it is assumed that:

these soils originally held 12.5 t C per ha to a depth of 10 cm

10 per cent of this carbon has been lost from 80 percent of this area as a result of agricultural use.

According to these preliminary estimates, the cumulative amounts of carbon lost from Australian soils since European settlement are *approximately*;

600 Mt C in periodically cultivated soils and

450 Mt C in other agricultural soils including rangelands.

It should be noted that the figure for cultivated soils indicates that the carbon-accumulating pasture phase of the rotation is insufficient to offset the carbon decreases caused by the cropping phase. It should also be noted that the figure for the cultivated soils represents a net loss from the whole of that area, whereas the figure for the rangelands represents the loss only from the degraded areas. In other parts of the grassland areas, where pasture improvement has been carried out, carbon is being assimilated (see related paper by Gifford, Barrett and Ash). Nevertheless, the *degraded* rangeland areas and the cultivated areas both have the capacity to sequester carbon.

The above figures are based on broad averages and should be viewed only as estimates with a fair degree of uncertainty. They need to be verified by more detailed studies and data analysis. In particular, we see merit in developing a methodology which takes account of the impact of soil type and agroecological zone on the organic matter loss process. However, these figures provide a reasonable first approximation of the amounts of carbon lost and, conversely, of the ***potential*** for sequestration. On the basis of these figures, it is clear that there is a very large potential to sequester carbon into agricultural soils in Australia. To take advantage of this potential sink it will be necessary to implement a number of changes to current agricultural practices.

Capacity to Sequester Carbon

Given time and the right conditions (eg. increased levels of crop residue input into the soil, reduced cultivation, reduced rate of breakdown of soil organic matter, etc), it is well established that soil carbon levels can be built up again following a period of rundown. Ideally the carbon levels can be restored to the same values that were supported the soils in their virgin state under native vegetation. In some instances the soils may be capable of sustaining higher organic matter levels than in their virgin state due to increased levels of fertility resulting from fertiliser applications.

Significant changes in agricultural practices would be required to achieve worthwhile increases in organic matter levels in these soils. Some of the changes required are already being implemented, including: control of weeds using small amounts of chemicals instead of cultivation; and return of crop residues to the soil instead of burning. Other changes, such as moving to higher input systems to produce larger amounts of both harvested crop and crop residues, are still in the early stages of implementation. It would take some time for the industry as a whole to assimilate and implement all of these changes and would probably require some inducement such as tradeable C-credits. The technologies required already exist but a significant effort would be needed to ensure their introduction and uptake with minimum net financial penalty.

In addition, the rate of build up of organic matter in the soil itself is a relatively slow process and will take many years to complete. This is especially the case for soils in which the fertility levels have been severely depleted. The slowness of this process will place limits on the amount of sequestration that can be achieved by 2013. On the positive side of the ledger, the build up of organic matter is not linear and the greatest rates of increase are found in the early years following change.

The annual rate of carbon sequestration is very difficult to predict because it will depend upon the extent of uptake of new agricultural production techniques. However, it is useful to give some indication of the levels of sequestration which could be achieved.

As a first approximation the following estimates are based ***only*** on 45-50 M ha of agricultural land that is closely managed. Let us assume that half of the total amount of carbon lost from these soils can be recovered over a twenty year period and that in any one year one third of the 45 M ha is in a recovery or organic matter build-up mode. On this basis, and assuming (for the purposes of this calculation) a linear rate of accumulation, the annual rate of sequestration of carbon by agricultural soils would be in the region of 4.4 Mt C pa. Looked at in another way, this figure represents an increase in soil organic carbon of ~0.3 t ha^{-1} yr^{-1} over an area of 15 M ha. This is perhaps an overly ambitious figure to be achieved, particularly in the early stages of implementation. A more conservative target of 2.2 Mt C pa based on the treatment of 7.5 M ha pa (roughly half of the annually cropped area) could well be achieved. Even so, this would represent a substantial contribution to Australia's greenhouse gas emissions targets. Any contribution that might be made through improvements in rangeland management would be additional but difficult to verify.

As well a changing arable agricultural practices, other activities which would promote organic matter accumulation are:

inclusion of larger areas and/or longer periods of pasture in rotational systems*

use of deeper rooting plants (legumes and other crops) to inject more carbon into the soil at depth#.

[Notes: **The companion paper on 'Pasture Improvement' by Gifford et al should be consulted for a more detailed consideration of pasture issues.*

#Generally, the carbon found at depth in soils has a slower turnover time than that found nearer the surface. A characteristic that may be usefully explored.]

It should also be recognised that this sequestration process would have a finite lifetime and would cease when the soils reached their new equilibrium organic matter levels after, say, 20-40 years.

Recommendation

There is considerable potential to sequester carbon into agricultural soils in Australia and it is suggested that Australia should argue for their inclusion in the allowable sources and sinks.

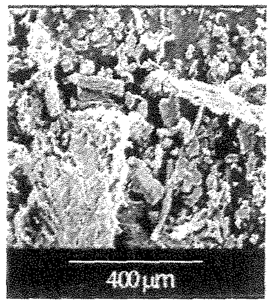
Reference

Russell, J. S. and Williams, C. H. 1982. Biochemical interactions of carbon, nitrogen, sulphur and phosphorus in Australian agroecosystems. In *The cycling of carbon nitrogen, sulphur and phosphorus in terrestrial and aquatic ecosystems* (Eds. I. E. Galbally and J. R. Freney), Aust. Acad. Sc., Canberra.

Achievement

A new simple, fast and inexpensive technique for measuring carbon in soils

CSIRO's technique will help predict the carbon status of any region in Australia.



Pictures of the fractions of carbon from plants and micro-organisms scanned using electronic microscopy.

Background

Soil carbon is stored in a number of fractions with widely varying chemistry and stability.

These soil carbon fractions can be converted to the greenhouse gas carbon dioxide, and comprise:

- rapidly decomposable raw pieces of plants and micro-organisms that lasts for days or weeks
- fine partly decomposed soil organic matter that takes years or even decades to disappear
- charcoal-like carbon from countless grass-land fire events that lasts for hundreds of years.

Now a quick and cheap way of determining the soil carbon content and the amount of carbon found in each form has been developed by CSIRO's soil organic matter research team to help predict the carbon status of any region in Australia.

Measuring carbon in soils is increasingly important world-wide due to its potential conversion to the greenhouse gas, carbon dioxide.

Until recently, measuring the carbon contents within carbon pools could not be determined accurately enough or economically.

Taking account of the net greenhouse gas emissions from land use will help us better understand and manage global climate change.

In Australia, a National Carbon Accounting System (NCAS) tracks greenhouse gas sources and sinks from the land.

Land-based sources and sinks are of key interest to Australia, forming around 30 per cent of the national emissions profile from activities such as land clearing, cropping, grazing and forestry.

The NCAS is used to:

- determine Australia's land-based sources and sinks
- track progress towards national emissions targets
- inform policies and programs in vegetation and land management.

The new technique

Until recently, measuring the amount of carbon within these different fractions, as required by the NCAS model, could not be determined accurately and cheaply enough.

A new rapid and inexpensive analytical method to determine the allocation of soil carbon to these fractions was therefore needed for practical use to provide information to the NCAS model.

Using mid-infrared (MIR) spectroscopy, the CSIRO team has been able to generate a spectrum of any soil similar to a 'fingerprint'. Such spectra contain a picture of all the various minerals and organic carbon fractions in the soil.

Fast Facts

- Soil carbon is stored in a number of fractions referred to as pools in a modelling context
- The chemistry and stability of the carbon found in each fraction varies widely
- Measuring carbon in soils is increasingly important world-wide due to its conversion to the greenhouse gas, carbon dioxide
- In Australia, a National Carbon Accounting System (NCAS) tracks greenhouse gas sources and sinks from the land
- This technique allows the NCAS system to rapidly predict the carbon status of any region in Australia

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Related Areas

Climate Adaptation Flagship
Understanding our Changing Climate
CSIRO Land and Water

Related Topics

Mr Mike Grundy: managing Australia's soil and landscape assets
Australian Soil Resource Information System (ASRIS)
Understanding the connections between land and atmosphere

Contact

Ms Mary Mulcahy
Communications Manager
CSIRO Land and Water

When this 'fingerprint' is combined with previous measurements of carbon fractions across a range of soil types and analysed using a complex mathematical process, the amount of carbon and its allocation to carbon fractions can be predicted easily for additional soils.

CSIRO's soil organic matter research team - including Mr Jan Skjemstad, Ms Janine Taylor, Dr Les Janik and colleagues - have developed a suite of analytical techniques to allocate soil carbon to each fraction. However, this process requires the use of a number of complex and expensive laboratory techniques.

The development of an MIR based method now makes these measurements both rapid and cheap.

How the technique will be used

The team describes the MIR technique in a paper recently published in the *Australian Journal of Soil Research*.

To use MIR spectra for carbon modelling, spectra from a large test set of calibration soil samples are collected and then combined with previously determined allocations of carbon to the soil fractions for each of the calibration soils.

Getting the laboratory data for calibration is very expensive but once it has been obtained only needs to be used once in the MIR prediction system.

The combined data is then analysed using a complex mathematical process called 'partial least-squares (PLS) analysis'.

The model from this process can then be used to easily predict the amount of carbon in its various forms for unknown soils.

This approach allows the NCAS system to rapidly predict the carbon status of any region in Australia and assess the role of soil carbon in budgets of global carbon so important to our strategies to manage climate change and has application throughout the world.

Find out more about our work in Understanding our Changing Climate.

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References

- Janik LJ, Skjemstad JO, Shepherd KD, Spouncer LR. 2007. *The Prediction of Soil Carbon Fractions Using Mid-Infrared-Partial Least Square Analysis*. In: *Australian Journal of Soil Research*. 45(2): 73-81.

Recommendations to Government and Business

SUSTAINABLE BIOLOGICAL AGRICULTURE

BIO-SEQUESTRATION – SOIL CARBON

- Support an high-powered Taskforce, linked to a Canberra university, responsible for overseeing the implementation of Sustainable Biological Agriculture (SBA) in Australia, based on appropriate natural science farming methods, including biological fertilisation and intentional planned grazing.

- Priority access to 'Caring for our Country' Program to implement Sustainable Biological Agriculture, including establishment of Commercial Demonstration Farms Australia-wide, with linked education, training and extension programmes for farmers and the broader community.

- Upon validation of the Sustainable Biological Agriculture technologies/systems and land/water management processes involved, Australia should adopt an objective (via progressive milestones) to convert 80% of all Australia's agricultural and range lands to SBA, by 2020 - to bio-sequester 300 million tonnes of CO_2e per annum as Soil Carbon.

- Soil Carbon to be recognised as part of the solution to sequestering carbon in Australia's Global Climate Change policy (post Kyoto), with farmers able to generate recognised offsets to the CPRS (ie, a tradeable soil carbon credit).

- CSIRO and other Science Institutes to assist in establishment of Soil Carbon estimation, measurement and accounting systems and to quantify the lower nitrous oxide and methane emissions from reduced nitrogenous fertiliser and chemical use (at commercial scale on the Commercial Demonstration Farms) including profitability analysis and other environmental and food–quality benefits.

SUSTAINABLE BIOLOGICAL AGRICULTURE

BIOLOGICAL FARMING – *An efficient, environmentally responsible farming system*
SOIL CARBON - BIOSEQUESTRATION OF CO_2 - *A powerful solution to Global Warming*

1. BACKGROUND

The Carbon Cycle

All soils contain a percentage of carbon. Carbon is predominantly sequestered into the soil system via plants – plants capture CO_2 through photosynthesis.

In Australia, human activity including land clearing, poor grazing practices, poor land cultivation techniques, stubble burning and the use of chemical fertilisers, fungicides and pesticides has significantly reduced the amount of carbon sequestered in soils. This has resulted in a marked reduction in the level of soil carbon in many of the country's agricultural regions (reductions estimated to average around 75%, ie, 150 - 200 billion tonnes CO_2e lost from agricultural soils Australia-wide since European settlement). This reduction in soil carbon has impacted the soil's ability to retain water, and microbiological activity in the upper soil profile. This has resulted in soil health decline, production decline, erosion, salinity issues and high cost of production. All threatening the viability of agricultural production.

Across the Australian dryland cropping and grazing sector it would now be unusual to find actively farmed soils with a carbon content of 1.5% or more. Normal soil carbon levels for quality agricultural soils should be above 5%.

Overgrazing, excessive cultivation, chemical fertilisers, and chemicals applications over the past century have collectively elevated carbon loss from soil and correspondingly elevated carbon dioxide and nitrous oxide emissions to atmosphere.

Soil carbon sequestration transfers CO_2 from the atmosphere into the soil, via photosynthesis by the crops and grasses, catalysed by the use of bio-organic fertiliser, with the CO_2 being captured and stored in the soil. Soil carbon sequestration is accomplished by farming systems that encourage increased amounts of biomass, use minimal tillage and enhance soil biota activity. Soil biology plays an important role in sequestering carbon in a stable form and bio-organic fertiliser is one way of rebuilding biological activity that has been destroyed by conventional farm practices.

The Opportunity for Australia

Australia has a huge carbon sequestration opportunity available to it through the restoration of its degraded soils. When extrapolated out across Australia's vast agricultural and pastoral regions (around 500 million hectares), this opportunity provides an offset for all the country's emissions for well over 40 years – enough time for new technologies to come on line and the economy to adjust. In addition, increasing soil carbon levels has economic benefits - the potential to increase productivity, improve drought and salinity resistance, and to reduce the need for costly inputs (ie, reduced chemical fertilisers, fungicides, pesticides and animal drenches, et al – which will yield healthier food and fibre). These benefits reduce the cost of the carbon offsets, thus providing Australia and the World with a low cost, environmentally beneficial pathway to a low carbon economy – a '**Carbon Bridge**'.

Estimates are that a 1% increase in soil carbon in just 10% of Australia's farmland could remove 10 years' worth of Australia's carbon emissions while a 4% increase in soil carbon could remove 40 years' worth.

Improved Farming and Fertilisation Practices

There are a number of ways to facilitate and increase soil carbon levels. They include:

- Restoration of the microbial, chemical and physical health of the soil. This increases plant nutritional balance and integrity and the natural recycling process resulting in more carbon being sequestered. Improving soil health and plant nutrition integrity elevates plants natural resistance to environmental impacts, including drought, frost, disease, and insect effects. This can be done on a large scale using biological fertiliser systems.

- Low impact cultivation. By reducing the disturbance of the soil, maintaining vegetation cover and avoiding stubble burning the physical and biological structure of the soil is allowed to develop. This process involves the formation of soil particles called macroaggregates – a long term storage site for carbon.

- Pasture and vegetation management. Through the careful management of grazing, previously worn out grasslands can be brought back to health. This increases the root and plant mass available for decomposition which in turn boosts the carbon cycle.

Benefits

The benefits of improved soil carbon, in addition to CO_2 sequestration, are many and include:

- Improved viability of agricultural producer.
- Elevated nutritional integrity of food and fibre produced.
- Opportunity of lower national health costs.
- Better plant resistance to pests and diseases.
- Increased ability of soils to store and transfer nutrients to plants, for greater productivity which can improve farmers' incomes.
- Increased soil water-holding capacity with better rainfall infiltration, holding the water until it can be used by the plants rather than letting it run–off/drain into waterways or evaporate, ie,., increased drought resistance.
- Increased soil stability which means greater resistance to erosion, which in turn means cleaner waterways.
- Unlocking of nutrient overload from synthetic chemical fertilisers.
- Increased recharge to groundwater and reduction or elimination of salination.
- Improved biodiversity: soil organic matter contributes to the health of soil microbial 'wildlife' and micro-flora which are the very start of the food chain.
- Healthier, climate-change compliant products that should avoid trade restrictions and attract premium prices.
- Elevated soil biology and mineral balance, translates to a significant reduction of chemicals, and chemical fertilisers used in agriculture, resulting in significant savings to national environmental and financial costs.

2. VISION

It is compelling public policy for Australia to adopt the Sustainable Biological Agriculture approach. This approach will benefit significantly the agricultural sector by improving soil quality and hence yields, and by reducing input costs with less need for expensive synthetic chemical fertilisers and insecticides/pesticides.

Australia to adopt an objective of the conversion of 80% of all Australia's agricultural and range lands to appropriate natural science farming methods, including biological fertilisation and intentional planned grazing (Sustainable Biological Agriculture) by 2020 – to bio-sequester 300 million tonnes of CO_2e per annum as Soil Carbon.

This Sustainable Biological Agriculture system will incorporate, amongst others, the critical aspects of Natural Sequence Farming, a biological approach to fertiliser use and the adoption of intentional planned grazing. It will remain open to new developments in this field and encourage their adoption where appropriate.

3. SUMMARY

Sustainable Biological Agriculture is an established, proven farming system.

Sustainable Biological Agriculture is a powerful international solution to Global Warming. Implemented in conjunction with renewable energy and energy efficiency policies it will allow the offset of emissions from the use of fossil fuels.

Sustainable Biological Agriculture is a lower cost, more efficient and environmentally cleaner farming system that significantly reduces the dependence on synthetic chemical fertilisers and produces healthier food and fibre.

Sustainable Biological Agriculture provides a long-term '**Carbon Bridge**' that will allow an effective, efficient, managed and financially positive transition to a low carbon economy.

Building Soil Organic Carbon using Biological Farming Systems in Australia's more Intensive Agricultural Regions

The capacity for appropriately managed soils to sequester atmospheric carbon is enormous. Soil represents the largest carbon sink over which we have control. When atmospheric carbon is sequestered in topsoil as organic carbon, it brings significant additional benefits to agricultural productivity and the environment.

Biological Farming Systems (BFS) is a pursuit of agricultural practices that creates soil mineral balance, promotes organic soil carbon and increases healthy soil biota to ensure sustainably productive soils.

Building Soil Organic Carbon (SOC) requires two things: green plants and soil microbes.

Soil microbes: The lost link in current intensive chemical agricultural practices

"Soil is alive with trillions of minute organisms that recycle nutrients and help plants grow. Soil is the engine room of life. The sun provides the energy, the plants convert and store it and the soil organisms drive the whole system. Australia's soils are in trouble. They are increasingly being poisoned with salt and chemicals. Many areas are compacted and eroded. Our soils are tired and over worked." Healthy Soils Australia

Application of BFS in Agriculture

BFS restores the microbial, chemical and physical health of the soil. This increases plant nutritional balance and integrity and the natural recycling process resulting in more carbon being sequestered. Improving soil health and plant nutrition integrity elevates plants' natural resistance to environmental impacts, including drought, frost, disease and insect effects.

BFS can be implemented on a large scale using biological fertiliser inputs and methods that promote soil biota. A key inclusion in this system is humus, currently derived from Victorian lignite (brown coal) and blended with solid and liquid plant nutrients and other biological stimulants.

BFS is used by over 300 farmers on over 300,000 hectares in Australia. Below are the benefits these farms are gaining.

1. Reduced chemical fertiliser use, including:
    - Nitrogenous fertiliser, reducing relative Nitrous Oxide (GHG) emissions
    - Chemically treated phosphate fertiliser
2. Reduced incidence of pest and disease and subsequent use of insecticide/fungicide sprays
3. SOC increases of up to 1.2% over 3 years and maintained with continuous cropping
4. Healthier stock (requiring less veterinary attention and mineral supplementation)
5. Pasture quality improvements, including species mix and resistance to dry periods
6. Soil water infiltration and holding capacity improved – drought proofing/reduced water use
7. Better soil fertility index – mineral balance, biological activity and physical structure (friability)
8. Return of natural soil biota – dung beetles, earthworms, beneficial bacteria and fungi, et al
9. Higher quality produce with maintained or greater production levels

Scope for BFS in Australia

Economical and practical implementation of BFS are viable in more intensive agricultural production regions. Currently BFS are used in a variety of production systems across low, medium and high rainfalls; primarily broad acre cropping, pasture, dairy, viticulture and horticulture – over 300 Australian farmers covering over 300,000 hectares.

Australia's rangelands (tropical savannas, temperate woodlands, shrublands and grasslands used for extensive grazing) are estimated to comprise approximately 288M hectares. The land areas devoted to more intensive agricultural production comprise approximately 167M hectares (National Land and Water Resources Audit). Australia's cropped area is 24.7M hectares which includes dry land and irrigated production.

Building SOC from Atmospheric Carbon Dioxide

Building SOC from atmospheric carbon dioxide requires two things: green plants and soil microbes. To turn 'air into soil' there are four natural plant and soil processes; photosynthesis, resynthesis, exudation and humification.

The final process, humification, stabilises organic carbon additions to soil so that the carbon gained from plant roots does not recycle back to the atmosphere as carbon dioxide. The process involves soil microbes to transform the carbon additions into stable humic substances which are long term stores of SOC (from decades to centuries).

Carbon additions from plant growth need to be combined with land management practices such as BFS that promote soil microbes and the conversion of transient forms of SOC to stable complexes within the soil.

BFS outcomes that promote soil microbial activity and subsequent stable SOC additions:

1. Minimise chemical use, buffer when appropriate
2. Reduce chemical fertiliser use and stabilise with a carbon source (humus based substances)
3. Maintain ground cover (residue retention and digestion)
4. Increase plant root growth (root exudates also feed soil microbes)
5. Condition soil with humus based inputs, primarily derived from lignite brown coal
6. Minimise soil disturbance through tillage
7. Avoid burning crop residues

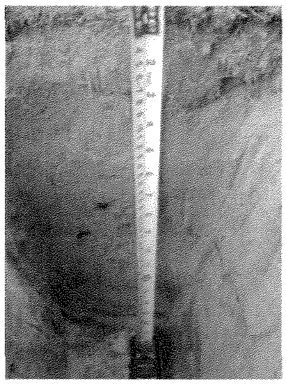

Image 1. Low carbon soil

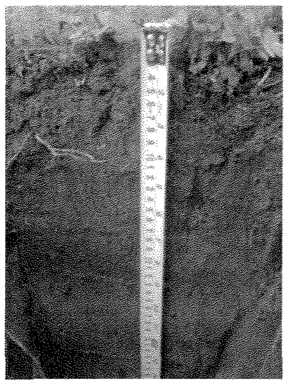

Image 2. High carbon soil

Soil which has a high SOC percentage is visibly darker in colour, which is partly due to the humus content of SOC. The soil in Image 2 (above) has used BFS for 12 years.

BFS CO_2 Sequestration Estimate

The estimate in Table 1 below uses Australia's cropped area of 24.7M hectares which is dry land and irrigated area, which is a relatively small component of what could be achieved across the more intensive agricultural production area in Australia (167M hectares). Greenhouse gas emissions in cropping production are currently high and increasing because of chemical fertiliser, pesticides/fungicides and diesel use as traditional solutions to production problems.

Table 1 below illustrates the significant quantity of atmospheric CO_2 that can be sequestered per annum by a given area adopting BFS with an absolute SOC increase of 0.15%. This increase is conservative and realistically achievable by adopting BFS. BFS field results have shown SOC to increase by 1.2% over 3 years in samples taken from the top 15cm of soil.

Table 1. ***Quantity of CO_2 sequestered (tonnes) by a total SOC increase of 0.15%, to 0-15cm soil depth and bulk density 1.5g/cm^3 over an area (Ha) in one year.***

Agricultural area treated with BFS (Ha)	As a % of the cropped Area in Australia (24.7M Ha)	Equivalent CO_2 sequestered per annum (tonnes)	% of Australian annual CO_2 emissions	Value of carbon credits
1		12.39		
200,000	0.8%	2,478,000	0.41%	$37.17 M
4,940,000	20%	61,206,600	10.2%	$918.1 M
12,350,000	50%	153,016,500	25.5%	$2.3 B

***Table 1 Assumptions*:**

1. Soil carbon content is usually expressed as a concentration (%). To convert from concentration to stock (t/ha) the depth of measurement and soil bulk density parameters are required. Standard soil sampling methods used in agriculture are to a depth of 15cm, however sampling to greater depths is recommended for future assessment. Soil bulk density (g/cm^3) is the dry weight (g) of one cubic centimetre (cm^3) of soil and varies with different soils and depths. Most soils range from 1.0-1.8 g/cm^3. An average bulk density of 1.5 g/cm^3 is assumed for the calculations. The soil carbon stock is determined by multiplying the carbon concentration (%) by the bulk density (BD) by the soil volume in a 15cm profile of a one hectare area.
2. Carbon dioxide equivalent sequestered will be calculated by multiplying the carbon stock by 3.67. Every one tonne increase in soil carbon represents 3.67 tonnes of carbon dioxide sequestered from the atmosphere.
3. SOC increase is a conservative 0.15% per annum. BFS field results have shown SOC to increase by 0.4% pa in samples taken from the top 15cm of soil.
4. Australian CO_2 emissions currently total 600M tonnes per annum.
5. Carbon credits are valued at $15 per tonne of CO_2 for calculations.

The conservative estimate is that 25% of Australia's annual CO_2 emissions can be sequestered by 50% of Australia's cropping area adopting BFS and subsequently increasing SOC.

OTHER CONTRIBUTIONS FROM BFS IN ADDRESSING CLIMATE CHANGE

Farmers using BFS make significant reductions in the quantity of chemical fertiliser used in the production system; with the added benefit of reducing potential emissions of Nitrous Oxide. Changes in the use of inorganic nitrogen fertiliser range on BFS farms from reductions of 30% and up to 100% of previous use.

GRDC Research Updates report Nitrous oxide (N_2O) is a greenhouse gas that can be emitted from agricultural soils and is of particular concern as it has 310 times more global warming potential than carbon dioxide and contributes to the destruction of the ozone layer. Overseas research suggests that 1.25% of all inorganic nitrogen fertiliser is emitted as N_2O from cropped soils. In Australia almost 90% of the increase in N_2O emissions (from 1990-1999) has been attributed to an increase in the rate of nitrogen fertiliser use. The main strategies proposed to minimise N_2O emissions from agricultural soils are to improve the efficiency of nitrogen fertiliser use and to minimise the incidence of water logging. (Nitrous oxide emissions from cropping systems - GRDC Research Updates)

Table 2. An example from 400 hectare broad acre cropping property in the Mid North of South Australia, reducing nitrogen inputs by 86%, with potential reductions of 58.8T CO_2 equivalent per annum over the property.

Fertiliser Use Compared	**Phosphorus** Units or kg	**Nitrogen** Units or kg	**N_2O Emissions** (kg) Over 400 Ha	**CO_2 Equivalent** (kg) Over 400 Ha
80-100kg/H1 DAP 60kg/Ha UREA **(2005) Pre BFS TOTALS**	**18**	**44.2**	221	68,510
30-50kg/Ha 15:13:0:9 Growth foliar 2-3 L/Ha (x2 app) **(2008) BFS TOTALS**	**5.4**	**6.25**	31.25	9,687.5
Fertiliser reduction/ **Potential Emissions Saved**	12.6/Ha **(70%)**	**37.95/Ha** (86%)	**189.75**	**58,822.5**

Summary Points

- ✓ Building soil organic carbon on half of Australia's cropping regions (12.3M hectares) has the potential to sequester over 150M tonnes of CO_2 (one quarter of Australia's annual CO_2 emissions) each year through the adoption of Biological Farming Systems.
- ✓ Potential for CO_2 sequestration from 167M hectares of more intensive agricultural production in Australia using BFS to build SOC is over 2 billion tonnes annually.
- ✓ Lowering emissions of nitrous oxide from reduced inorganic fertiliser use with BFS
- ✓ BFS results in a carbon neutral application of lignite brown coal

GROWING SOIL CARBON IN AUSTRALIA'S GRAZING RANGELANDS

RANGELAND OR GRASSLAND SOIL CARBON

The rangeland or grasslands in pastoral zones of Australia (excluding national parks, Aboriginal reserves and other government exclusions) comprise some 437 million hectares or 57% of the national land area. These areas are predominantly found in lower rainfall zones. Importantly, in these zones rainfall is usually erratic and/or seasonal. About 95% of Australia has low, erratic or seasonal rainfall characteristics, and much of our grassland is seriously degraded. Soil carbon levels are believed to have dropped considerably due to our use of inappropriate grazing practices.

Because rangeland productivity per hectare is much lower than in more intensive cropping regions, the properties in such areas are usually very large, and they are often great distances from distribution points, farmers cannot economically or practically apply any form of advanced technological solution to the declining grassland production or to deteriorating landscape health. The primary beneficial change that can be effected on a wide scale is a significant change of management to use intentional planned grazing methods. These methods recognise, respect and restore the key features of the global, naturally occurring relationship that exists between soils, plants and grazing animals.

THE NATURAL SOIL > PLANT > GRAZING ANIMAL RELATIONSHIP IN SEASONAL ENVIRONMENTS

For millions of years, natural function in seasonal environments has involved the movement over the landscape of large herds of tightly bunched animals. The Serengeti is a remnant of this natural function. While on other continents many of the grazing animals are ruminants, in his book *The Future Eaters,* Tim Flannery showed that before their extinction there were a number of species of large, non-ruminant animals that played a similar grazing role within Australia's ecology.

In natural environments, tight bunching occurs due to the presence of pack-hunting predators. In the absence of such predators, grazing animals rapidly spread out and halt their constant movement. A large, bunched and constantly moving herd evenly consumes a considerable volume of plant material. In addition the animals deposit concentrated masses of dung and urine onto plants and the soil surface, and they trample large volumes of plant material directly onto the soil surface, thus both covering and protecting it. The immediate positive effect of this treatment is a fouled and unpalatable environment that takes months to recover. During this recovery phase the animals are reluctant to return, and where possible they will deliberately move on to land that has had sufficient time to fully recover. The long-term effect of this complex inter-relationship is healthy, covered soils and abundant, vigorous plant growth.

CURRENT CONVENTIONAL MANAGEMENT PRACTICES ARE OFTEN THE OPPOSITE OF NATURAL FUNCTION

Current management practices within the vast Australian rangelands are often the direct opposite of natural function. Animals are typically spread out in numerous small herds across large areas of land for a long time – usually months or years - as opposed to hours or several days at most as natural function dictates. They are held within fences and so unable to move to fresh ground. The outcome of this management is a significant loss of biodiversity. The symptoms of this biodiversity loss include visibly degrading landscapes characterised by increasingly large areas of bare soil, and gradually declining plant populations and associated animal productivity losses.

Fortunately all these biological symptoms can be reversed, and this reversal requires no new, additional, or as yet untested large-scale technological development. The required management changes and subsequent improvements can begin immediately managers choose to commence intentional planned grazing.

MIMICKING NATURAL PROCESSES

To date in Australia it is estimated that between 8 and 11 million hectares are under some form of management that mimics this natural function. The essence of the technique used is to combine the many small herds into large mobs. These herds are then moved from paddock to paddock in a carefully planned and intentional manner. They remain in each paddock for one to several days at most, and return to that paddock only when the plants are fully recovered from the grazing, which is usually after weeks to months or even longer.

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THE GRASSLANDS EXIST BECAUSE OF PHOTOSYNTHESIS

Plant growth is a biological outcome of a process known as photosynthesis. Briefly, during the photosynthetic process inorganic carbon that is contained within atmospheric carbon dioxide (CO_2) is converted into the various forms of organic carbon compounds that together make up the many large and small plants that sustain all life on earth. This mass of plant and associated plant-consuming organisms is, collectively, biodiversity.

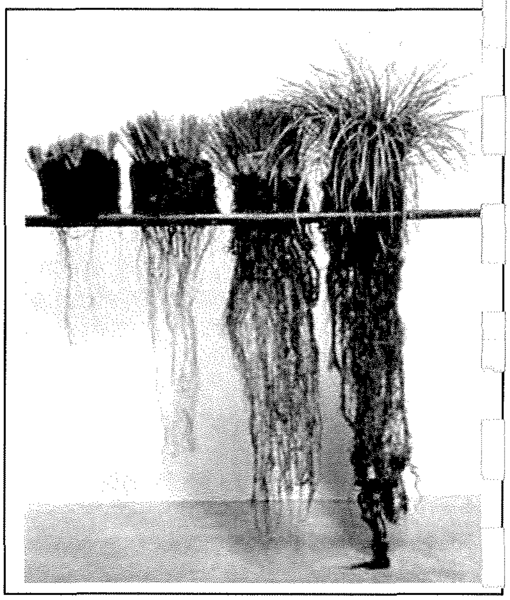
HOW GRASSES GROW

The grasses growing in the rangelands (and elsewhere) all act photo-synthetically just like trees in a forest. They grow as the photosynthetic process proceeds. Specifically looking at grass growth, science shows that when in balance, large leaf masses above ground are always supported by similarly large root masses below the soil surface, and this vegetative material is carbon rich – around 58% elemental carbon. The RH pot in the photo below demonstrates a balanced, healthy plant.

THE *PLANT* > *ANIMAL* RELATIONSHIP

Grass plants grow on a sigmoid basis. If left un-grazed, at some stage in their growth the above-ground or leaf and stem portions of the plant begin to change their cell structure. The cells in the above ground parts of the plant begin to lignify or become 'woody'. If left ungrazed the plant begins to suffer and will eventually die of *'over-rest'*.

On the other hand, plants can also be grazed too early. When a plant is grazed, the natural balance between above ground and below ground structures is disturbed. Just as it is not possible to sustain a large leaf mass upon a small root system, neither is it possible, post-grazing, to sustain a large root system below ground when there remains a smaller post-grazing leaf mass above ground.



Immediately following the act of grazing the plant begins to slough off some of its roots, trying to restore balance to its structure. This material is 58% carbon by weight, the building block of soil carbon. Given time, as post-grazing leaf growth recommences the plant will begin to build new roots to replace those it sloughed off. It does this in order to maintain balance as it recovers from the grazing that was so necessary to sustain its life.

During this period of post-grazing recovery though, the plant is at risk of *'over-grazing'*. If the plant is bitten again before it has fully rebuilt its root system there is a net damage to the plant. If frequent biting is allowed to continue for too long, the plant will die from root destruction directly arising from too frequent grazing. The LH pot in the photo to the right shows a balanced but very unhealthy plant that is close to death, having been 'grazed' too frequently.

THE KEY COMPONENTS OF THE NATURAL *PLANT* > *ANIMAL* RELATIONSHIP:

1. Ungrazed grass plants become increasingly unpalatable and useless to grazing animals
2. In order to avoid death from over-rest, grass plants must be periodically grazed before they begin to lignify
3. If grazed a second time too soon after a previous bite, plants will die of over-grazing

When plants experience periodic, timely grazing and re-grazing both they and the animals that depend on them remain strong, healthy and productive.

THE NATURAL *SOIL* > *PLANT* RELATIONSHIP

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Carbon is transferred into the soil as exudates from growing roots, and as decaying carbon rich material whenever roots are sloughed off following periodic grazing as described above. In fact, up to half of the carbon captured by the grass plant during photosynthesis can be released into the soil surrounding the plants roots. This carbon is the food that fuels much of the amazing life found in a truly healthy soil.

When the soil surface is correctly managed with intentional planned grazing, much of the carbon that is captured from CO_2 and converted to root material will remain in the soil. Over time and under appropriate management, Soil Carbon levels will increase. When Soil Carbon levels are rising there will be increasing biomass both above and below the soil surface. In addition, as elemental carbon is black in colour, the soil will get darker in colour.

HOW MUCH SOIL CARBON MIGHT ACCUMULATE UNDER APPROPRIATE MANAGEMENT?

Prof. Peter Grace (Queensland University of Technology) has provided the following table which estimates the Ipotential national scale of Soil Carbon sequestration in Australia. He has used the SOCRATES model in this estimation. Prof. Grace's numbers are consistent with the calculations of Prof. Keith Paustian from Colorado, who was an IPCC lead author on soils.

Soil carbon change and CO_2 consumption per annum				
Soil type	**Area (M ha)**	**C increase (t/a)**	**Total Mt C**	**Total Mt CO_2**
Calcarosol	42	0.12	5	18
Chromosol	16	0.74	12	43
Dermosol	7	0.74	5	19
Ferrosol	4	1.23	5	18
Kandosol	90	0.51	46	168
Kurosol	3	0.74	2	8
Rudosol	42	0.12	5	18
Sodosol	69	0.74	51	187
Tenosol	89	0.12	11	39
Vertosol	75	1.48	111	407
TOTAL	**437**		**253**	**927**

Estimated areas of each soil type within the >200mm average annual rainfall zone (adjusted for area loss due to National Parks etc) (Grace)

IN SUMMARY

- ✓ Grazing rangelands occupy 57% of the national land area
- ✓ Because of their scale, location and productive capacity it is not financially viable to apply technology based interventions on a wide scale
- ✓ Some 8 to 11 million hectares of Australian rangelands are now managed using the techniques described in this document
- ✓ It is known that Australian soils will sequester CO_2 under appropriately changed management
- ✓ Australia's soils offer a valuable, immediate and lasting contribution to mitigating climate change
- ✓ Appropriate management will likely increase the tonnages able to be sequestered within Australian rangelands beyond those indicated in this paper

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Summit partners:

U.N. Development Program
Government of Sweden
Government of Denmark
U.S. National Parks Service - Beringia Heritage Program
U.S. Arctic Research Comission
National Pacific Research Board
The Denali Commission

Source: www.indigenoussummit.com

Article 6

Involve farmers who live off the land

The UN Food & Agriculture Organisation (FAO) is urging policy makers to include agriculture in negotiations for a new climate change treaty to replace the 1997 Kyoto protocol, as agricultural land is able to store and sequester carbon.

April 2009, Rome - FAO has urged policy makers to include agriculture in negotiations for a new climate change treaty to replace the 1997 Kyoto protocol.

"Agricultural land is able to store and sequester carbon. Farmers that live off the land, particularly in poor countries, should therefore be involved in carbon sequestration to mitigate the impact of climate change," said Alexander Mueller, FAO Assistant Director-General on the occasion of the ongoing UN negotiations on a future international climate change agreement in Bonn.

Agriculture accounts for about 14 percent of greenhouse gas emissions, and land use changes such as deforestation for another 17 percent.

"While agriculture is contributing to greenhouse gas emissions, farmers and their families, particularly in poor countries, will also become victims of climate change. It will worsen their living conditions and hunger and malnutrition will increase. Rural communities dependent on agriculture in a fragile environment will face an immediate risk of increased crop failure and loss of livestock. Mostly at risk are people living along coasts, in floodplains, mountains, drylands, and the arctic," Mueller said.

"That is why agriculture needs to be put on the agenda of global climate change negotiations. Existing financing mechanisms under the Kyoto Protocol allow only a very small fraction of the mitigation potential of agriculture to be realized and are therefore not sufficient," Mueller noted.

Emitting greenhouse gases

Crop production and livestock release greenhouse gas emissions into the air such as methane from cattle and wetlands, especially rice paddies, nitrous oxide from fertilizer use and carbon from deforestation and soil degradation. Changes in land use such as deforestation and soil degradation - two devastating effects of unsustainable farming practices - emit large amounts of carbon into the atmosphere, contributing to global warming.

Annual greenhouse gas emissions from agriculture are expected to increase in coming decades due to increased demand for food and shifts in diet.

"But millions of farmers around the globe could also become agents of change helping to reduce greenhouse gas emissions," Mueller said. By keeping higher levels of carbon in the soil - a process known as "carbon sequestration" - farmers can help reduce carbon dioxide levels in the air, enhance the soil's resilience and boost crop yields.

Reduced tillage, increased organic soil matter, increasing soil cover, improving grassland management, restoring degraded lands, planting trees, altering forage and sustainable use of animal genetic diversity, using fertilizer more efficiently, improving water and rice management, are options farmers can apply to mitigate greenhouse gas emissions in agriculture.

"Massive investments in agriculture are required to change unsustainable production methods, to train farmers in climate change mitigation practices and to improve overall access to credit and information," Mueller said. "These investments will make agriculture more resilient to climate change and at the same time will improve agricultural productivity and sustainability, thus contributing to better food security and poverty reduction."

Insufficient incentives

"Current global funding arrangements, like the Clean Development Mechanism under the Kyoto Protocol, are inadequate and are not offering sufficient incentives for farmers to get involved in climate change mitigation and adaptation," Mueller said.

"For example, soil carbon sequestration, through which nearly 90 percent of agriculture's climate change mitigation potential could be realized, is outside the scope of the Clean Development Mechanism under the Kyoto Protocol. Neither climate change mitigation, nor food security, nor sustainable development, benefit from this exclusion," Mueller added.

Carbon markets that provide strong incentives for public and private carbon funds in developed countries to buy agriculture-related emission reductions from developing countries could provide important investments to spur rural development and sustainable agriculture in developing countries. Product standards and labels could be developed to certify the mitigation impact of agricultural goods.

THE STATE OF FOOD AND AGRICULTURE 2008

Also see BIOFUELS: prospects, risks and opportunities

Source: www.fao.org

Article 7

Carbon reduction tools from WWF & Telstra

How Information and Communication Technology (ICT) can improve environmental sustainability for large organisations and deliver positive commercial outcomes, a new White Paper introduces a set of tools to enable Australian organisations to estimate the benefits of ICT investment.

Public release date: 25-Aug-2008
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Back To EurekAlert!

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IFDC

TVA fertilizer technology used worldwide -- but few new products since 1970s

$41 million in TVA research returned $57 billion to the world; IFDC officials call for new generation of fertilizer research

About 75% of fertilizers and fertilizer technology used around the world today were developed or improved during the 1950s to 1970s by scientists and engineers at the Tennessee Valley Authority (TVA) in the United States, says John Shields, a former TVA official. Shields is now Interim Director of the Research and Market Development Division of IFDC, an International Center for Soil Fertility and Agricultural Development, based in Muscle Shoals, Alabama.

TVA developed 75 percent of the fertilizers used worldwide today -- but research and development in fertilizer technology has almost ceased since the program closed in the early 1990s.
Click here for more information.

"An investment of $41 million in fertilizer research through 1981 returned an incredible $57 billion to U.S. agriculture," Shields says. "That doesn't include benefits of the technology to the rest of the world."

But inadequate public funding caused closure of the TVA fertilizer research program in the early 1990s. Today, publicly funded fertilizer research and development has essentially ceased—and so has the flow of new and more efficient fertilizers and fertilizer manufacturing technologies.

Dr. Amit Roy, IFDC President and CEO, says, "TVA's fertilizer program is recognized as one of the most effective research and development programs of any U.S. agency. Its benefits to the world far outweigh the public investment that the United States made in fertilizer research and development.

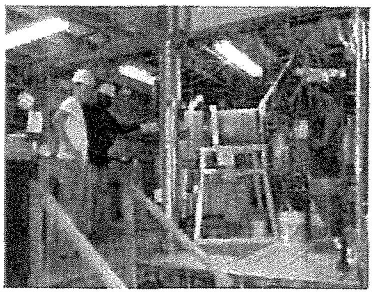
"It's time to launch a radical initiative to develop a new generation of energy-efficient fertilizers to help avert hunger and famine."

TVA Achievements

TVA developed high-analysis fertilizers with high nutrient content as well as more efficient manufacturing processes. The fertilizers include urea, diammonium phosphate (DAP), triple superphosphate (TSP), sulfur-coated urea, and liquid fertilizers. TVA improved the manufacturing processes for ammonium nitrate and other products that help commercial producers provide efficient fertilizers to farmers worldwide. TVA's ammonium-granulation and bulk-blending technologies improve the efficiency of the manufacture of many mixed fertilizer grades. TVA generated most of the fluid fertilizer and dry bulk-blending technology used in the United States today.

"TVA technology fueled the sweeping advances of U.S. farmers in food and fiber production in the 60s to 80s," Shields says. "Today, fertilizers are responsible for more than a third of total U.S. crop production.

"The $57 billion return from a $41 million investment included about $49 billion from use of high-analysis fertilizers and $8 billion from process development and



IFDC has six pilot plants for research and training in fertilizer development and production.
Click here for more information.

improvement. That's a benefit:cost ratio of more than $20 to $1.

"TVA followed promising new fertilizers from conception to production to national acceptance by farmers and the fertilizer industry," Shields recalls. "Its program was based on fundamental research, followed by process development and technology transfer."

After agronomic tests and pilot plant production proved that a new TVA fertilizer product or manufacturing process performed well, TVA produced enough tonnage to introduce it into U.S. agriculture. "TVA then stopped work on that project and moved to develop newer and more promising technologies," Shields says.

Calls for New Fertilizer Research

Dr. Norman Borlaug, 1970 Nobel Laureate, says, "I am concerned about the state of the fertilizer industry itself. With the price of energy increasing, we need to find cheaper, more effective ways to nourish food crops. The price tag for increasing productivity in Africa will be quite high. The fertilizer industry needs to do everything in its power to minimize that cost. Farmers are paying way too much for fertilizer products because we are transporting millions of tons of material that is not nutrient and because much of the nutrients in applied fertilizers are never used by the crop. Nutrient losses to the environment are high with consequences for global warming and water pollution.

"Work should begin now on the next generation of fertilizer products using advanced techniques such as nanotechnology and molecular biology, especially in conjunction with plant genetics research. 'Smart' fertilizer products that will release nutrients only at the time and in the amount needed should be developed." Borlaug served on the IFDC Board of Directors from 1994 to 2003.

"The world needs a major research effort to improve the effectiveness of fertilizer production and use," says Peter McPherson, President of the National Association of State Universities and Land-Grant Colleges (NASULGC) and current Chairman of the IFDC Board. "Fertilizer is a commodity industry and it is unlikely the industry alone will undertake the research. Some public investment is probably required."

During the U.N. Food Summit in June 2008 in Rome, more than 180 world leaders addressed the food crisis and stressed the urgent need "to decisively step up investment in science and technology for food and agriculture."

IFDC Facilities

"The need for increased food is escalating, but new agricultural technology is not keeping pace," Roy says. "An effective research program to develop a new range of fertilizers should be a key element of any long-term strategy to alleviate the food crisis.

"Most fertilizer products used today were developed when energy seemed abundant and cheap. But with rising prices we should develop a new generation of fertilizer products that use plant nutrients more efficiently.

"Such innovations will require investments in research—but such costs would be miniscule compared to the benefits for humanity," Roy says.

"IFDC is in a unique position to meet this challenge. We're the world's only agency with the necessary facilities and expertise. We have both the physical and human resources to do the job. IFDC has a complex of six pilot plants for research and training in fertilizer development and production plus a highly qualified team of scientists and engineers. We also have the international contacts to build support for a new, vigorous fertilizer research and development program.

ABC News

Digging into soil carbon warrants study

By NFF president David Crombie

Posted Tue Mar 31, 2009 9:21am AEDT
Updated Tue Mar 31, 2009 9:25am AEDT

How much carbon is agriculture absorbing? Nobody knows, and this is where Australia can truly lead the carbon debate. (ABC TV News - file image)

Scientists worldwide recognise the very real opportunities for reducing greenhouse gas emissions in the atmosphere through storing carbon in biological systems.

The Inter-Governmental Panel on Climate Change, Australia's own Garnaut Report on Climate Change and, indeed, the Australian Government have all confirmed carbon capture - including through soils, crops and pastures - is a reality.

One problem is realising the potential. How do we monitor, measure and evaluate the net emissions and/or storage of carbon across Australia's 155,000 farms?

Federal Agriculture Minister Tony Burke recently announced $32 million to study the role soil plays in storing greenhouse gases.

This biosequestration occurs naturally through the process of photosynthesis. Farmers facilitate photosynthesis as they plant crops, encourage pasture re-growth and sustainably manage vegetation to ensure their land continues to be productive. In fact, over 94 per cent of Australian farmers actively employ natural resource management practices as a matter of course.

However, the international carbon accounting rules, set by the United Nations Framework Convention on Climate Change, misguidedly focus on carbon emissions and fail to recognise biosequestration through agricultural or any other means.

This is not only short-sighted but, frankly, ignorant. If governments are serious about tackling carbon pollution, then they need to fully understand the total carbon cycle - how much is being emitted and how much is being sequestered. This then needs to be fully accounted for in any carbon trading regime.

Globally, agriculture makes up around 12 per cent of all emissions - in Australia, around 16 per cent. Even though Professor Garnaut and others have cited Australia as among the lowest emitting farm systems on Earth, while producing food and fibre for everyday human existence, we're told it's still too high.

But what of the other side of the ledger? How much carbon is agriculture absorbing? What is the 'net' carbon effect of this biological release and capture on the environment? Nobody knows, and this is where Australia can truly lead the carbon debate.

We've seen grossly misleading assertions by those with an ideological, sometimes zealot-like, position regarding agriculture's 'major' contribution to global warming. However, such claims come from a factual vacuum, ignoring carbon being removed from the atmosphere through farm practices.

In effect, when it comes to carbon and agriculture, the public is only getting half of the story.

While opportunities through biosequestration are real, there are variables. Different farms will have varying capacities to store carbon in their soil, depending on soil types, rainfall patterns and production systems.

Nevertheless, for those with the right preconditions, building soil carbon can have additional positive spin-offs through improving water retention capacity of soils and enhancing vegetation's ability to soak up nutrients.

That's why the National Farmers' Federation is calling for an 'opt in' approach, alongside the Government's Carbon Pollution Reduction Scheme (CPRS).

It is universally agreed agriculture cannot be covered by the proposed CPRS, and may never be. But there must be capacity for the sector to contribute to carbon reduction in a positive way.

Through research and development on soil carbon, we can explore human-induced sequestration opportunities throughout the complete biological system.

From what we already know, farmers can start designing appropriate, voluntary, market-based means that incentivise maximising soil carbon - and other forms of biosequestration - through complementary activities to the CPRS.

As new research findings and opportunities come to light, these activities can, and should, expand to reduce atmospheric carbon levels.

In fact, a new report by McKinsey and Company, Pathways to a Low Carbon Economy, not only notes the "very large" potential for carbon sequestration in soils, but goes further in saying it could be delivered "at a neutral cost or - net-profit-positive to society and require no substantial capital investment".

But, as I have alluded to, this is all academic without international carbon accounting rules changing to take stock of the full carbon cycle.

At present, the rules penalise countries who seek credit sequestering activities through soils, crops and pastures by making them liable for carbon from unforeseen and unavoidable natural disasters, such as droughts and bushfires.

Proactive countries, including Australia, are effectively shut-out from gaining carbon credits because of these unreasonable penalties.

We are encouraged by the Australian Government's commitment to reforming the rules, seeking to delink sequestration and natural disasters. Meanwhile, we should not be deterred from pursuing positive actions to increase soil carbon sequestration.

And, more pointedly, if the goal is to reduce carbon emissions, then regardless of accounting rules and trading schemes, shouldn't we be doing it anyway? If we're to be hamstrung from what we know works because of an accounting construct, then, I would suggest, the powers that be have missed the point.

For our part, Australian agriculture has a positive role to play. We need to be allowed to get on with the job of sequestering carbon through farm systems, while continuing to deliver food and fibre Australians - and the world - are increasingly relying on.

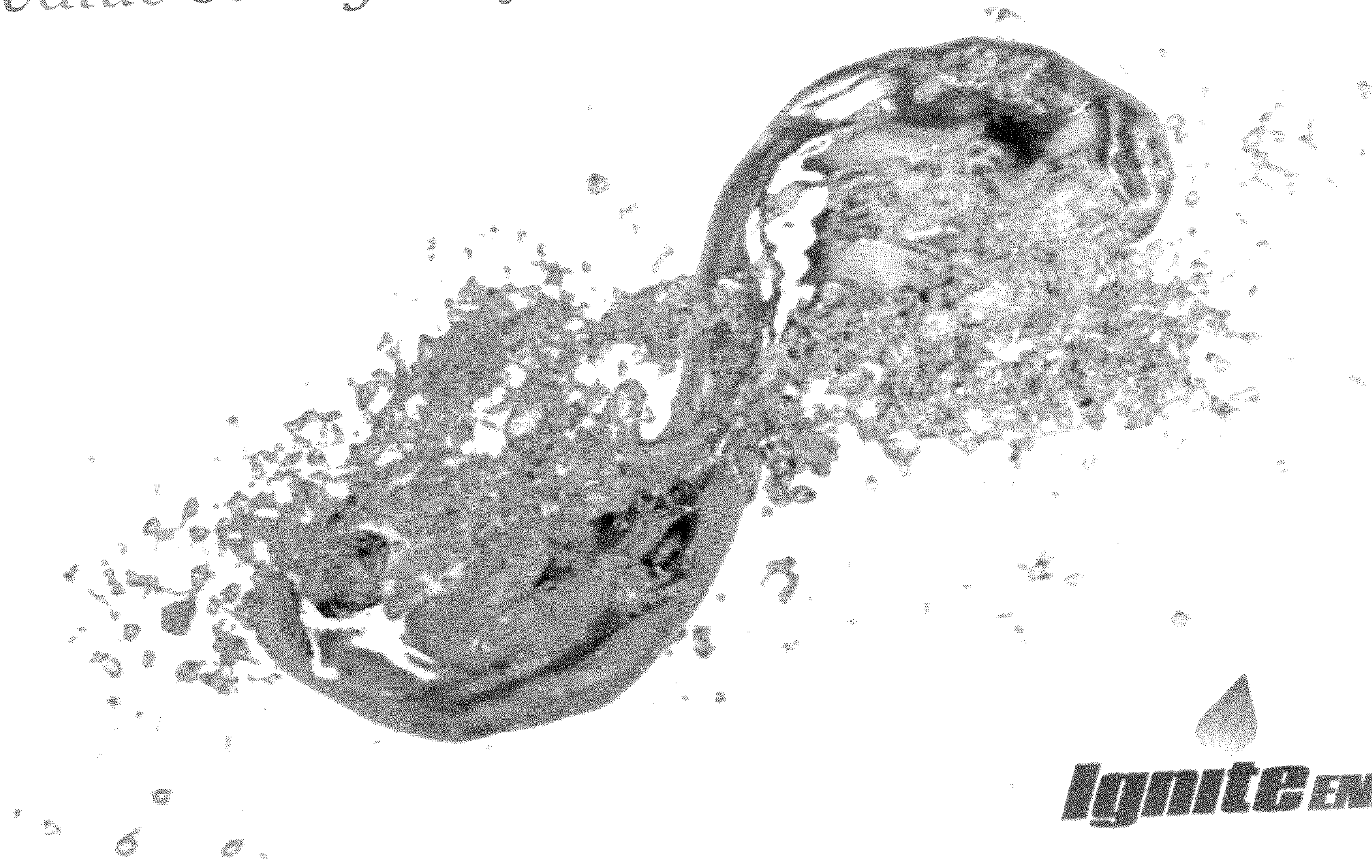
David Crombie is president of the National Farmers' Federation.

Tags: environment, climate-change, rural, australia

Ignite Energy Resources - IER

A convergence of nature and technology

Transforming brown coal (lignite) into high-value biological fertiliser



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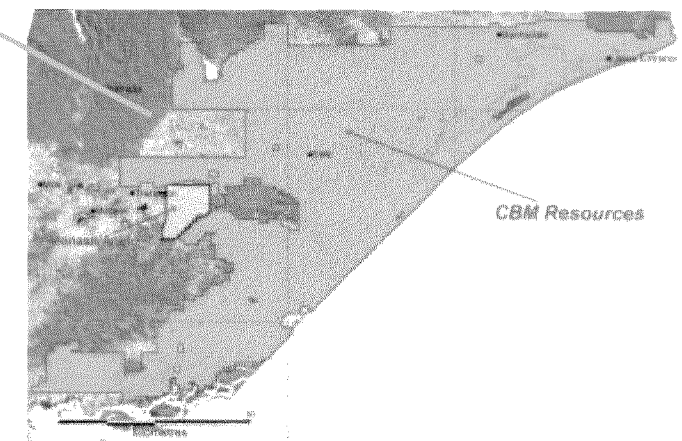
EL 4416 – a world-class lignite resource

Exploration Licence (EL) 4416 - onshore Gippsland Basin, Victoria, Australia – approx 3700 km² and 200-300 billion tonnes (Bt) of brown coal in place

Independent Expert Reports - JORC standard ~ 18 Bt of lignite in three deposits – amongst the cleanest coal in the world – low ash, sulphur, salts, etc



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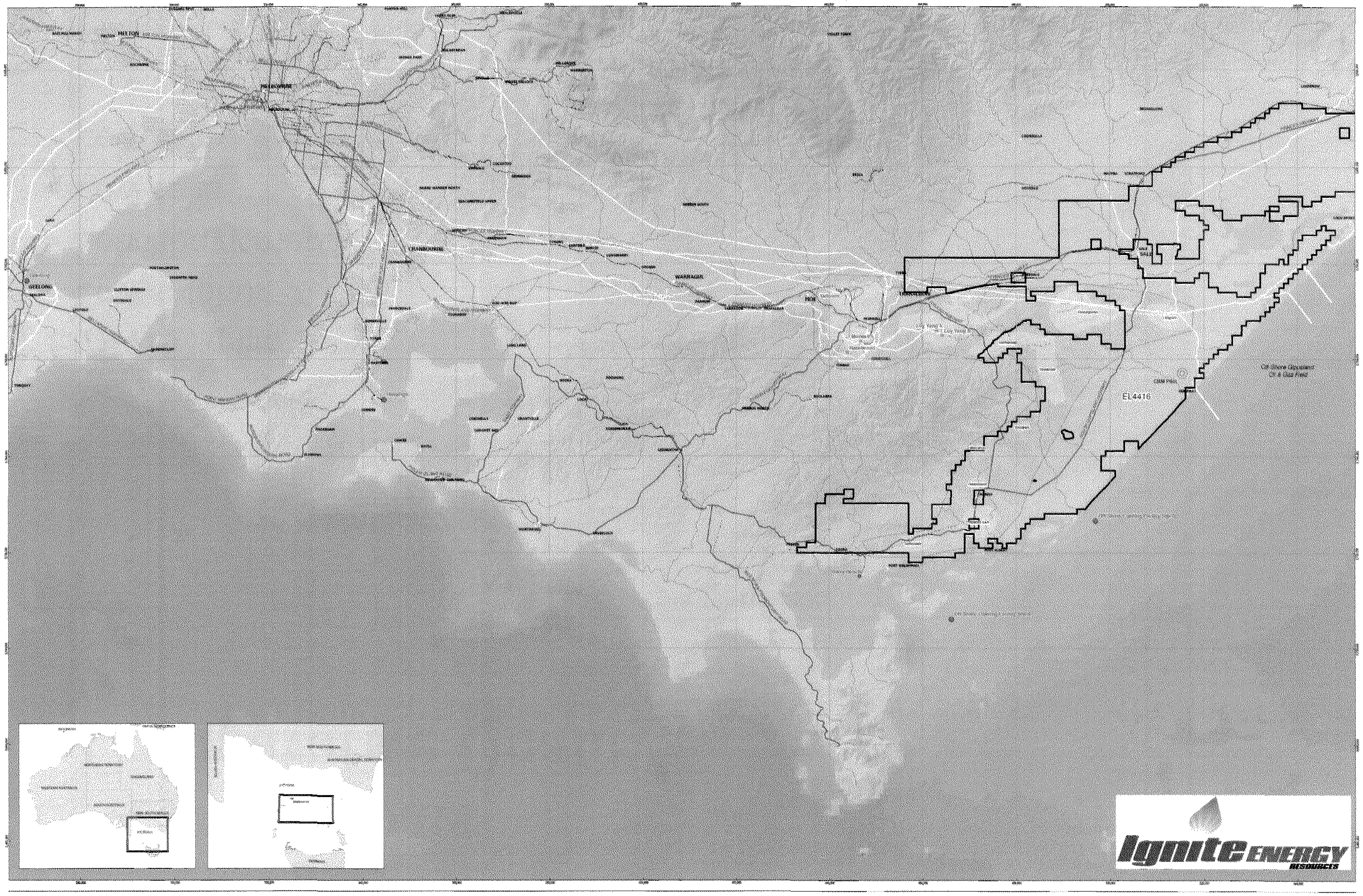
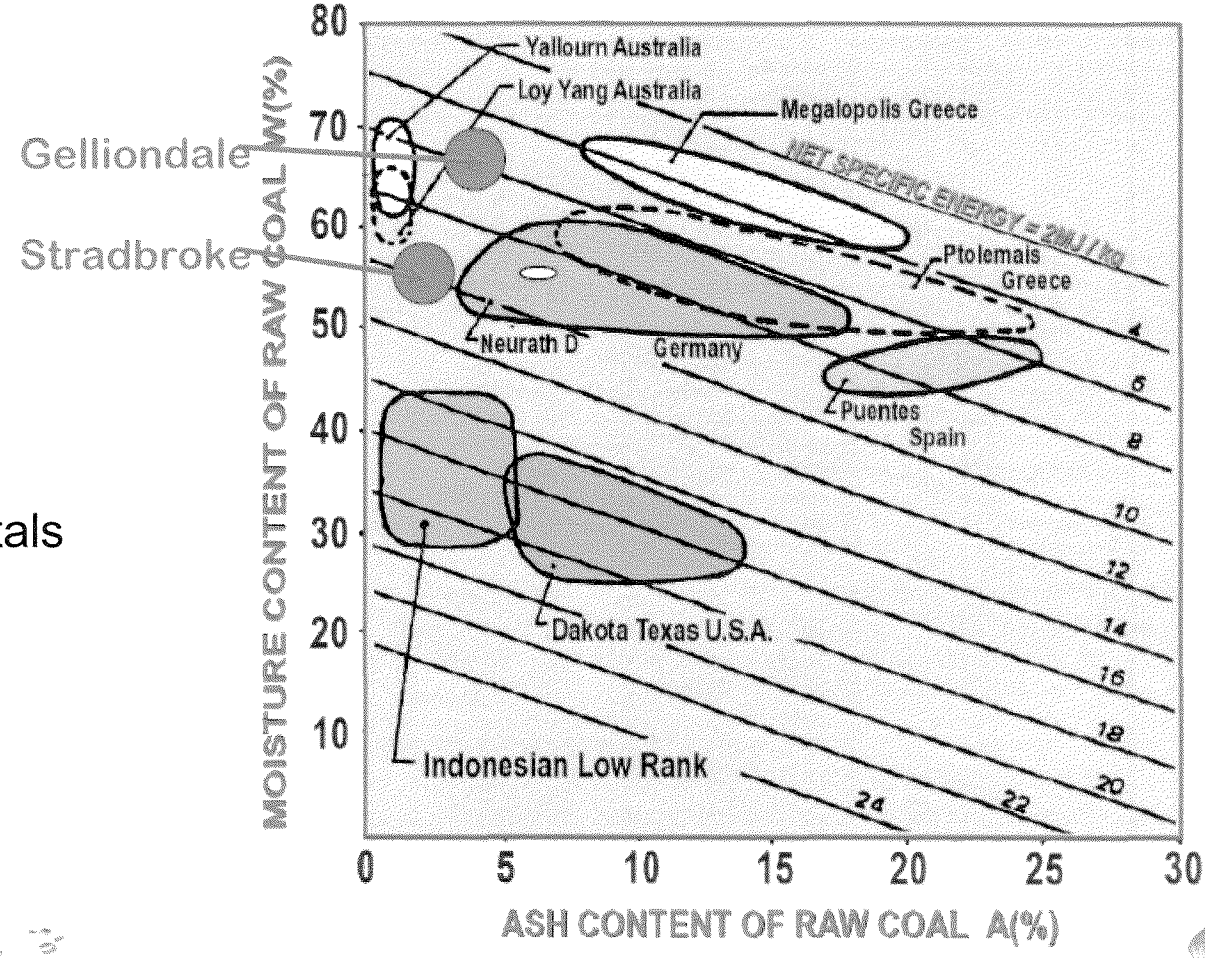
The Strzelecki Arc – EL 4416



Low Rank Coals
– Comparative Quality



EL 4416 lignite

- Low sulphur
- Low heavy metals
- Low salts
- Low ash

Lignite based BioLogic fertiliser CO_2 sequestration - replacing chemical fertiliser

- **Conversion of lignite to high-grade BioLogic fertiliser**
  - proven LawrieCo technology - with three existing factories
  - Biological farming/fertilisation system (BFS) improves farm profits
  - BFS already deployed on 300 farms over 300,000 hectares
- IER/LawrieCo JV to roll-out BioLogic fertiliser plants on EL 4416
  - IER's lignite uniquely suitable due to high humic/fulvic content
  - close to port for national distribution and export
  - existing high-value market for BioLogic fertiliser
- BioLogic fertiliser, blended from lignite with proprietary biology, catalyses crops & grasses to rebuild soil carbon & biological diversity
- Measured **soil carbon increase** – min 0.15% pa (~15 tonnes CO2 per ha from ~50kg lignite application) – **300 x carbon multiplier**

High carbon content soils are rich, brown, fertile, drought resistant, healthy soils

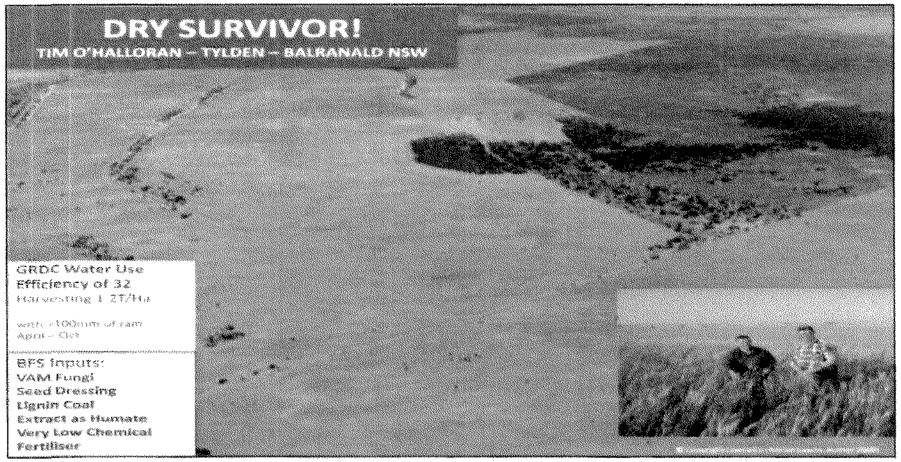
Ignite ENERGY RESOURCES

Greening brown coal
IER's zero net emission strategy

- Australia's agricultural lands (~500m ha) have been degraded of soil carbon (average 3-4% down to ~1% – being 150 to 200 Bt CO_2e) equivalent to ~300 years of Australia's annual GHG output
- 1 M ha BFS farmlands – min 15 Mt CO_2 sequestered pa
- 0.2% increase in soil carbon on 5% of Australia's agricultural land equates to 500 million tonnes of CO_2 sequestered

BFS can offset Australia's fossil fuel emissions for many decades, at very low (arguably negative) cost of CO_{2e}

CARBON BRIDGE



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