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Land & Water Link

Australia needs a 'true blue' land use system


Photo: Bill van Aken

Wheat farming in the Murrumbidgee Irrigation Area

CSIRO research is pioneering an innovative solution to the problems inherent in Australia's current land use system: galloping acidification and salinisation, deteriorating soil structures and declining water quality.

The answer is to revert to a 'true-blue' land use system tailored to the unique Australian environment, rather than persist with the current model which European settlers imposed on the antipodean landscape some 200 years ago.

This brave new approach is being pursued by a new CSIRO program titled 'Redesigning Australian Plant Production Systems'. The program is a collaborative effort by several CSIRO divisions (Land and Water, Soils, Plant Industry, and Tropical Agriculture) and the University of Western Australia. It is funded jointly by the Land and Water Resources Research and Development Corporation (LWRRDC) and CSIRO.

Program coordinators are Dr Phil Price of LWRRDC and Dr John Williams of CSIRO Land and Water. The aim of the research is the design of innovative methods for matching managed production systems and practices to the natural environments of Australia.

'It is important to realise the distinction between this new approach and the old, which focuses on seeking discrete incremental advances towards the sustainability of existing practices', explains Dr Williams.

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'In other words, many existing practices and systems are inherently flawed no matter how hard we try to adapt them – they are at odds with the natural Australian landscape and should be radically altered or discarded. A key research tool is the study of remaining native ecosystems – natural scrub and bushland. These can then be used as benchmarks for analysing existing systems and practices, and for moulding new ones.

'At the core of today's acidity and salinisation problems is the relatively poor uptake of rainfall, groundwater and nutrients by introduced crop and pasture species, in contrast to the situation that existed prior to the clearance of native vegetation.'

As Dr Williams says, 'Our agricultural system leaks. If we can stop it leaking, we can arrest the rate of soil decline.'

A typical farm in the Mediterranean climate regions of Australia can lose 200 millimetres of water and 70 kilograms of nitrogen from every hectare each year. The water tops up the water table, causing it to rise, and brings salts to the surface in the process; while the nitrogen loss results in acid soils toxic to plants. Both processes spell lost income for farmers and for Australia.

'We need crops and pasture systems which are better designed to take up nutrients and water. We need better rotations that use more water and nutrients from the soil, and we need to get away from annual monocultures and experiment with mixed crops. We need also to include more perennial crops, pastures, shrubs and trees – native Australian species in particular – in our farming systems.

'It is very clear that many established agricultural practices are failing the test of long-term sustainability. New approaches, which parallel the natural balances that existed prior to settlement and which are in harmony with the unique biophysical characteristics of the Australian environment, are urgently required.

'Without a change to more environmentally sustainable systems and practices, the day will come when the landscape is completely ruined and the rural milch cow will dry up.'

Dr Williams points to a long list of benefits set to flow from his brave new world of contaminant-free production and high-quality land and water systems, not least of which is the maintenance of Australia's valuable rural exports: meat $2.5 billion; wool $3.5 billion; cereals and grains $2.8 billion; sugar $1.4 billion; cotton $0.6 billion; wine $0.4 billion; and fruit $0.4 billion. He adds that our exports are already being challenged by anti-contaminant trade barriers and by marketplace preferences for food and fibre which are clean and produced without damage to the environment.

Other benefits would include a significant reduction to the current expenditure of $2 billion on imports of solid timber and paper products; an increase in exports of high quality woodchips; a net improvement in fertiliser efficiency, saving up to $90 million annually; enhanced turnover of soil organic matter and nutrients; improved soil structure and reduction of erosion; clean water and enhanced environmental amenity of rivers, streams and estuaries; and stable biodiversity.

The program's research activities focus on five main areas: manipulating water and nutrient uptake to minimise leaching;

Photo: Ian White

Acidic groundwater seeping from an embankment into a drainage canal

modelling the processes which result in soil acidification; water and nitrogen economies of native sandplain communities and their comparison with adjacent agroforestry and conventional agriculture in the WA wheatbelt; innovative soil and water management in the Mediterranean climatic zone (WA); and a modelling framework for assessing performance of natural and managed systems.

Dr Williams says the damage to Australia's soils is of prime concern. 'The greatest problem is structural decline, caused by such things as too much tillage, crop rotations that are too tight and incompatible species of crops or pastures. Fortunately, there are answers on the way for the soil structure problems.'

The next greatest threat, according to Dr Williams, is the widespread acidification of soils. 'As yet there is no Australian farming system which can significantly halt the rate of acidification. Land cleared of native vegetation tends to go acid at a rate of about one pH point every 35 years. This means that in under a century some soils will become so acid that nothing will grow, because aluminium is released from the clays.'

Erosion caused by wind and water is still very common, particularly in parts of Western Australia and South Australia. 'But here too, new practices such as direct drilling, and contour farming are beginning to succeed.'

Salinisation of soils is a very serious problem, costing at least $300 million a year. 'So far there is no real evidence to suggest we are close to turning it around.'

The fifth threat to the nation's soil resource is nutrient decline, especially on parts of the rich, cracking clays of northern NSW and Queensland. 'We are literally mining precious nutrients, particularly nitrogen and phosphorous, at an unsustainable rate', says Dr Williams.

Put it all together and we see widespread damage to one of the world's poorer soil resources – Australia – at a time when there is great pressure on our farmers to increase productivity.

The challenge for the Redesigning Australian Plant Production Systems project is to develop an array of agricultural and forestry practices capable of sustaining the overall quality of Australia's unique landscape – 'a true-blue land management system!'.

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Photo: Bill van Aken

Denuded landscape, Kenya

Australia's global role in landscape sustainability

Deteriorating landscapes and water resources are global problems, and Australia has a key role to play in turning the tide back to environmental sustainability, according to the Chief of CSIRO Land and Water, Dr Graham Harris.

'World-wide, the approaches being taken to tackle such problems are far too fragmented to have much effect – and much better coordination is needed', Dr Harris says.

He believes many of the world's ecosystems are 'going downhill fast', listing as examples the Aral Sea, which he says is 'lost'; the Baltic, which is 'going'; and the widespread destruction of the landscape in Africa and South East Asia – 'the recent fires in the latter region illustrate the point'.

'Lough Neagh in Ireland is bright green with algae from excess nutrients and many other inland water bodies around the world have recurring toxic algae blooms, including some in Australia.

'There is a pressing need for landscape repair to become a world priority. What's required is an effort equivalent to that being exerted by the international community in tackling such problems as the Greenhouse Effect', states Dr Harris.

He argues that Australia is uniquely qualified to lead an international campaign for a global focus on repairing landscape degradation, and has committed CSIRO Land and Water to promoting this idea at the Federal Government level.

'In government agencies such as the Murray-Darling Basin Commission and the Great Barrier Reef Marine Park Authority, we have world-class models which demonstrate how complex environmental systems with multiple uses can be sustainably managed.

'We also have grassroots movements like LandCare and Greening Australia, which are skilled at developing action plans at the community level and which are already admired internationally.'

Dr Harris says the ball is already rolling in the direction of Australia playing a pivotal role on this issue at the international level. 'Our fast-growing environmental industry is becoming very good at exporting its products, and we have world-class land and water science to underpin it all.

'Perhaps our greatest strength is our long experience in managing fragile, often arid landscapes and water systems – some of which have been poorly managed in the past.

'Relatively recent revelations as to just how fragile much of the Australian landscape is, have given us an acute awareness of the urgent need for conservation and remediation.

'Humanity is now starting to face some very hard decisions about how we use our landscapes and everything in them – this encompasses trees, soils, water, biodiversity and the air that surrounds them. But at the moment, humanity does not have good answers for how to address degradation problems on a large scale.'

According to Dr Harris, what is needed is a 'new agenda': an approach which contrasts with some of the more extreme forms of environmentalism, which he terms 'deep-green agendas'.

'The new environmental science is not the small-scale bandwagon academic research we have seen 'til now, but broad landscape and region-scale research with a practical, earthy tinge to it – mud on the boots stuff!

'In the Murray-Darling Basin, for example, we need to show that if we put the trees back in the right way, we can improve salinity, restore the rivers, bring back biodiversity, protect our soils and create new industries and jobs – all at the same time.'

Dr Harris believes Australia has a two-fold responsibility on the global landscape issue. 'Firstly, there is a moral responsibility as an enlightened nation to ensure that an environmental ethic permeates the world community. Secondly, we have a responsibility to share the scientific skills and experiences which we have, and which much of the world needs.

'By fulfilling these responsibilities, Australia will also reap considerable economic benefits – increasing its exports of vital technologies and know-how', Dr Harris concludes.

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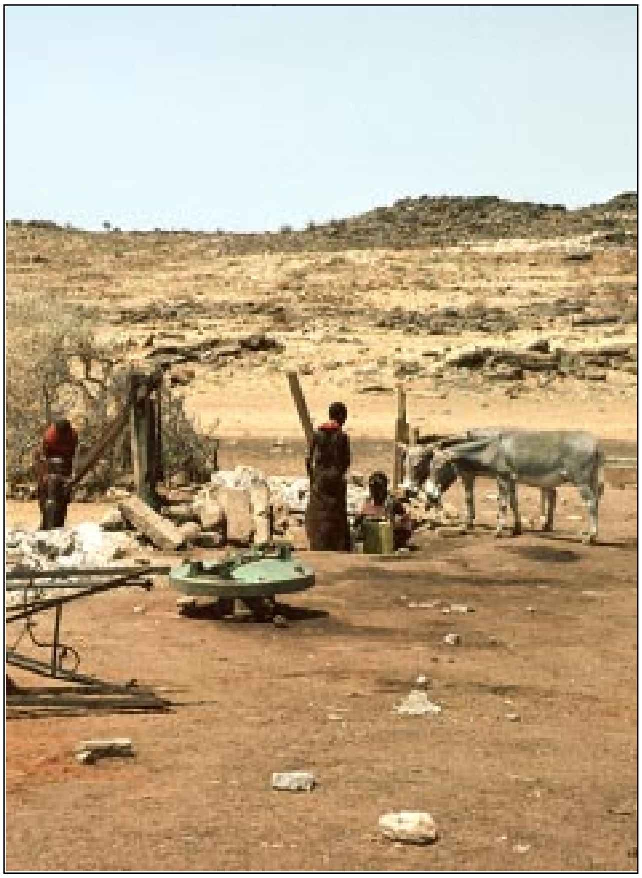

Photo: Bill van Aken

In search of water - an increasingly scarce resource in an arid environment

The Science of Wind Energy

Dr Peter Coppin of CSIRO Land and Water is a 'wind prospector' – one of a new breed who employ a sophisticated array of sciences to pinpoint the areas of richest energy potential in terms of landscape and prevailing winds.

Indeed, so competitive is wind prospecting becoming that something of a 'windrush' has developed, as energy producers race to identify and secure the best sites. With an extra one million dollars worth of energy flowing from a one per cent improvement in the life performance of your average wind farm, the windrush phenomena is easily explained.

Working with NSW energy supplier Pacific Power, Dr Coppin and his colleagues have struck gold – they identified a major wind 'hot spot' near Crookwell, in the NSW Southern Tablelands, soon to be the home of Australia's largest and first grid-connected wind farm. In the process of the Crookwell 'discovery' a whole new methodology was developed, a technique which has been recognised as world-class.

With a good wind, the Crookwell farm will pump out a steady 5 megawatts from eight 600kW propeller turbines, enough to meet the average electricity demand of at least 3500 homes. But that's not all – the farm will also produce a tidy little spin-off of an 8000 tonne annual reduction in greenhouse gas emissions through the replacement of fossil fuels.

The concept of wind-generated electricity fits perfectly into the Federal Government's greenhouse strategy, which has a target of 2 per cent of national energy needs being sourced from renewables.

'Our methodology will help make wind the most competitive form of renewable energy in Australia - capable of supplying the lion's share of the Federal Government's target. And in the longer run, it could provide an even larger slice of the national energy cake', Dr Coppin said.

Wind farms are already playing significant roles around the world. Denmark, the world leader, now draws over 7 per cent of its total electricity needs from the wind and plans to move to 40 per cent in the next few decades, exporting its surpluses to the rest of Europe.

The CSIRO team's methodology for finding rich wind prospects such as Crookwell is necessarily complex, involving a subtle blend of many sciences: fluid dynamics, topography, meteorology, demography, numerical modelling and statistics – to name a few. On the practical side, scores of 40-metre high towers are erected across the landscape to provide year-round monitoring of wind speed and turbulence.

'The technique has enabled us to find wind resources where most people would least expect them to be. It also assists in orienting the farm, and even individual turbines for optimum power generations.'

The key to successful siting of wind farms is not so much the power of the wind – though this is important – as the need for consistency at medium strength, explains Dr Coppin.

While most people consider that Australia's windiest regions lie along its southern coastline, the new methodology has amply demonstrated that there are plenty of rich resources inland too – mainly along mountain ridges and peaks where the moving air is 'squeezed' between the peaks and the atmosphere's lower layers.

In the case of Crookwell there is a large expanse of flat, open country which allows the wind strength to build up, and then a series of ridges which act like huge aircraft wings, kicking the wind upwards and increasing its energy as it passes over the top.

The cost of wind energy – and whether it can compete with coal-fired or other forms of electricity – is vitally dependent on the correct positioning of the turbines so that they can draw the most power from the wind, year-round. A site with an average wind speed of 5 metres per second produces almost double the electricity of one with 4 m/sec.

'The relative cost also depends on where you locate the generators, in relation to existing electricity supplies. It is costly to transmit electricity over long distances, so the economic viability of wind farms increases, the further out along the national grid you go', Dr Coppin adds.

Wind farms are sometimes criticised for their visual impact, but as Dr Coppin explains another advantage of the new technique is that it enables individual turbines to be 'micro-sited' in places where they not only draw optimum power from the wind but also impinge least on the landscape.

But there is a note of caution: many potential sites have maybe only one 'sweet spot', which might be fine for a single turbine, but a wind farm requires a group of turbines spaced several hundred metres apart for optimum viability. If placed too close, the turbines can interfere with each other; a problem which can be compounded by inconsistencies in wind direction.

'Nevertheless, Australia has an abundance of good wind farm sites and the day has arrived for us to call on many of them to provide us with abundant, clean, totally renewable energy for both homes and industry', says Dr Coppin.

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Photo: Greg Heath

Wind turbines - producing clean and sustainable energy for the future

Petroleum hydrogeology: assisting oil and gas industry

Photo: Richard Woldendorp, Photo Index

Off-shore oil rig, North west Shelf

They say oil and water don't mix. Try telling that to the CSIRO divisions of Petroleum, and Land and Water, and you'll get a quizzical response.

Both divisions have joined forces, together with contributions from the Australian Geological Survey Organisation (AGSO), to assist the oil and gas industry to more cost-effectively explore and extract the reserves of the North West Shelf, Australia's most prospective region. It is a touch ironical perhaps that the most significant tool being used in the project is the team's insight into the behaviour of groundwater.

The North West Shelf's huge hydrocarbon resources are embedded in reservoirs deep in the rock beneath the ocean floor. Over the ages, some of the faults which entrapped oil and gas began to facilitate leaks into other formations. In the Timor Sea region, for example, about half the identified reserves show some evidence of having leaked along faults over the past five million years.

With the backing of twelve of the nation's major petroleum resource companies, together with AGSO and the WA Government, Dr Najwa Yassir (CSIRO Petroleum Resources) and Dr Claus Otto (CSIRO Land and Water) have devised a method for assessing which faults are sealing or non-sealing, which reservoirs are leaking, and a way of forecasting where the petroleum is likely to have ended up.

Their technique has drawn heavily on the deep well of our scientific knowledge of water, which has been accumulated over the past 200 years on this the driest continent on earth.

'The physics of the flows is the same for both water and oil', Dr Otto explains.

'Our aim was to use applied hydrogeology, similar to that used by hydrogeologists to monitor groundwater, to find which faults have sealed tight and held the oil or gas, and which ones have leaked.

'By studying the dynamics of these underground flows it is possible to locate potential accumulations. This reduces the financial risk and saves exploration and production costs', he says.

The advances Drs Yassir and Otto have made are also enabling oil companies to more accurately estimate the size and physical characteristics of the fields they are exploiting, thereby providing a more accurate assessment of their productive life – vital information for forward planning.

In the course of the three-year program, which began last year, the research team will produce maps and a major quality-controlled hydrodynamic database for two of Australia's largest energy fields: the Carnarvon Basin and the Timor Sea. These will be available to those companies exploring for or producing oil and gas in the region.

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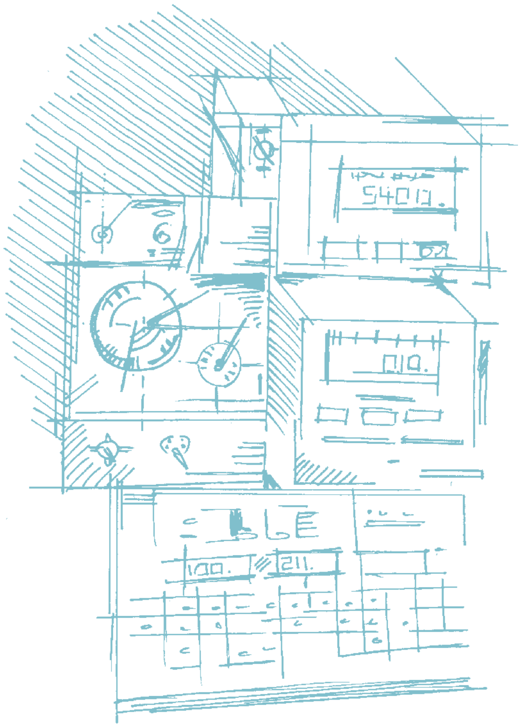

Computer software and GPS technology can be installed in conventional harvesters

Photo: Bill van Aken

Higher farm profits - precisely what's needed!

As the imperative for squeezing maximum returns from farm hectares and doing it sustainably looms larger and larger, CSIRO Land and Water has stepped forward with a research project which will greatly improve farmers' capacity to achieve both.

The project is refining the concept of Precision Agriculture and involves a happy mix of some of the world's highest technology (literally) and the down-to-earth common sense for which Australian farmers are renowned.

To understand Precision Agriculture is to understand the problem it has addressed. Farmers have long known that across paddocks of several hundred hectares there are wide variations in such things as soil fertility and ground moisture. But short of hopping on and off the tractor every few metres to alter the seed and fertiliser calibration devices on the machines they tow, farmers have had no choice but to make sweeping generalisations and apply the fertiliser and seed at the same rates across the entire paddock.

The CSIRO's Precision Agriculture research project, funded by the Grains Research and Development Corporation, at last provides farmers with a practical alternative. Using satellite global-positioning systems and state-of-the-art yield monitoring, the good and bad patches of crops are pinpointed, providing the means for corrective actions.

Project leader Dr Simon Cook points out that while the technology behind Precision Agriculture is sophisticated, the concept is not new. Dairy farmers, for example, have long been feeding individual cows differing doses of supplementary rations according to their personal production levels, instead of herd production levels.

'What Precision Agriculture has done is take the same principles from the controlled environments of intensive farm operations and apply them to the wide open spaces of the paddock', Dr Cook explains.

The environment is potentially a big winner. Precision Agriculture can help ensure that only as much herbicide or insecticide as necessary goes on to the ground or crop. Not only does this save money, but also the impacts on the environment are kept to an absolute minimum.

'Any tendency there might have been to over spray – just to make sure – is gone. And areas that don't need spraying can be avoided.'

The basic tool of Precision Agriculture is the 'yield map': a map of variations in grain yield across the paddock, which is easily used to plot corresponding variations in gross margin. The yield variations are provided by yield monitoring devices installed in conventional harvesting machinery. They provide instantaneous readings of grain flow with an accuracy in the order of 97%.

Research groups in the US report technological developments which promise to expand the range of attributes which can be measured continuously to include grain moisture, protein content, straw, soil organic matter, soil moisture and soil nitrogen.

The monitors have greatly increased the 'precision' of agricultural management and from all accounts it's a popular concept. Sales of yield monitors for headers have grown from a few hundred in the early nineties to about 30,000.

The second ingredient for a yield map is the precise location of where each crop yield measurement was taken. This is possible using the spatial referencing capabilities of satellite global-positioning systems (GPS), which have positional accuracy of 1-3 metres anywhere in Australia. A similar process can be used to pinpoint inputs such as weedicides, fertiliser and seeds.

A Gross Margin Map drawn for a CSIRO trial on a wheat crop at Newdegate in Western Australia, which had appeared viable overall, in fact revealed almost 30% of the area as showing a negative gross margin. The remainder showed a profit that varied from zero to over $100 per hectare.

'In other words a great deal of the paddock was running at a loss, which prior to mapping would not have been revealed', Dr Cook explained.

Having determined that the response to inputs does vary within a paddock, farmers then need to apply these inputs (fertiliser, seed, weed sprays) at the appropriate rates to suit the different sections of their paddocks. A wide variety of spreaders and sprayers with variable-rate controls are now available. These are either controlled manually within-cab, or automatically by reference to an onboard digital map.

Dr Cook stresses that the sophisticated gadgetry and the comprehensive information it gathers, won't of itself provide benefits. 'Far from diminishing the farmers' roles, the system requires improved decision-making by them.'

He has identified four stages in the cycle of increasing precision with agricultural practices: observation, interpretation, evaluation and implementation. For example, after the yield map has identified a low profit/yield patch in the paddock (observation), it is

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then the farmer's common sense and local knowledge which must answer the question of why this occurs.

'The district might be known as prone to poor water penetration resulting from sodic soil (interpretation). Analysis of a quick sample of the soil from the flat spot would confirm this (evaluation) – leading to a decision to apply gypsum (implementation) to correct the problem.

'At all stages, local skills and common sense are vital to the process.'

The research shows that the benefits of Precision Agriculture appear very significant – from increased efficiency with the use of inputs; reduced risk of environmental hazard due to excessive application of inputs; and improved control over farm processes.

At another trial on a Western Australian wheat farm, the farmer would have lost about $8/ha had he applied urea at the recommended rate of 60 kg/ha. Variable rate treatment generated an average additional profit of approximately $17/ha, mainly by avoiding losses over non-responsive areas.

About one-third of the paddock did not respond positively to urea at all, so application would have been a complete waste of money.

'Indications are that across wide areas of the Australian farm landscape, extra returns could be sufficient to cover the additional costs of mapping and variable rate control, which are likely to be in the order of $5-$15/ha', Dr Cook concluded.

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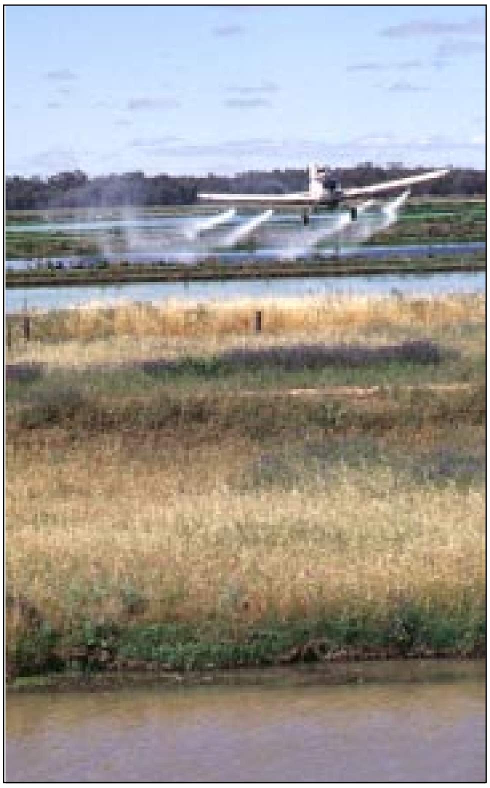

Photo: Bill van Aken

Precision Agriculture allows farmers to minimise the environmental impacts of aerial spraying

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