A warm welcome to Pine Ridge. This information bay is first stop in a self-guided tour set up by the Landcare Group.

Pine Ridge

A catchment in good hands

On an overcast day in April, CSIRO technician Peter Richardson bids hello to a curious companion: a green tree frog, living most contentedly down an observation well, beside a road called Cattle Lane.

Richardson unplugs the frog, dubbed Froggo, and passes it to me. It hops sticky-footed up my arm, then settles on my camera while the groundwater table is measured and sampled for electrical conductivity (salinity).

Due to an unseasonal dry spell, the water table is 2.2 metres below the surface, almost a metre lower than the previous reading taken in December. It usually hovers between 1.5 and 2 m, the critical depth at which salty groundwater can be drawn upward by capillary rise.

The salinity reading, echoed at 10 other wells across the sub-catchment, is 19.9 decisiemens per metre (dS/m). That's a little saltier than when last measured, and far saltier than any farmer would wish. Anything over 2 dS/m, or 4% as salty as seawater, spells trouble for conventional agriculture.

Cattle Lane intersects the 35 000 ha Yarramanbah/Pump Station Creek sub-catchment, located just north of the Liverpool Range, at the southern end of the 1.2 million-hectare Liverpool Plains catchment in northern New South Wales (see map).

CSIRO Land and Water technician Peter Richardson has befriended a family of green tree frogs while taking watertable measurements in the Pine Ridge sub-catchment.

In the 1830s, the Liverpool hills and ranges were heavily timbered and perennial grasses swathed its fertile, alluvial plains. A drive through the region today reveals cattle, sheep and erosion where the trees had been, and crops – sorghum, sunflowers, cotton, wheat and barley – on the plains. Less than 15% of the original vegetation remains.

Clearing has transformed the Liverpool Plains into one of Australia's highest-yielding cropping and livestock regions, with an annual production value of more than $150 million. It has also upset the region's water balance in a potentially dangerous way.

In the early 1990s, some 195 000 ha (16%) of the Liverpool Plains were estimated to be at risk from salinisation, with groundwater tables less than 5 m from the surface. Farming on the black clay plains is under threat and the salinity of surface water exported from the catchment is rising, raising fears of further problems downstream.

Community concerns about rising saline water tables led to the formation in 1992 of the Liverpool Plains Land Management Committee, an umbrella organisation which coordinates research, development and extension in natural resource management. Soon after the committee formed, the Liverpool Plains became one of five focus catchments in the National Dryland Salinity Program.

As the program entered its first year, seven progressive farming families from the Yarramanbah/Pump Station Creek and adjoining Warrah Creek catchments formed the Pine Ridge Landcare Group, one of 46 such groups affiliated with the Liverpool Plains committee. The families, initially concerned about increased flooding and waterlogging in the area, have since worked collectively to protect the productivity of their land.

Pine Ridge landholders have contributed to a number of research projects under the National Dryland Salinity Program, sharing information with scientists and allowing experimental sites and observation wells – such as the one occupied by Froggo – to be established on their properties. A major outcome relating to these studies, due for completion in 1999, will be land-use recommendations for groundwater management across the Liverpool Plains.

In the meantime, Pine Ridge Landcare Group is investing heavily in change, encountering in the process many challenges confronting similar groups across Australia. These include understanding and monitoring local groundwater systems, weighing risks, setting goals, seeking technical and financial assistance, and trying out land-use strategies that 'use water where it falls'.

According to water level data gathered in the past 25 years, groundwater levels in the deep aquifer at Pine Ridge have been rising at a rate of 4 cm a year, and salt levels are rising in the nearby Mooki River. This is due to the combined effects of land clearing and the constricted geology of the sub-catchment.

By the 1950s, trees on the sedimentary hills and slopes had been largely replaced by sheep, cattle and wheat. At this time, as tractors became more powerful, annual crops and long fallows progressively replaced perennial grasses on the heavier, black-clay plains. Annual crops allow more water to escape below their root systems than native vegetation, adding on average some 20 mm a year to the groundwater system.

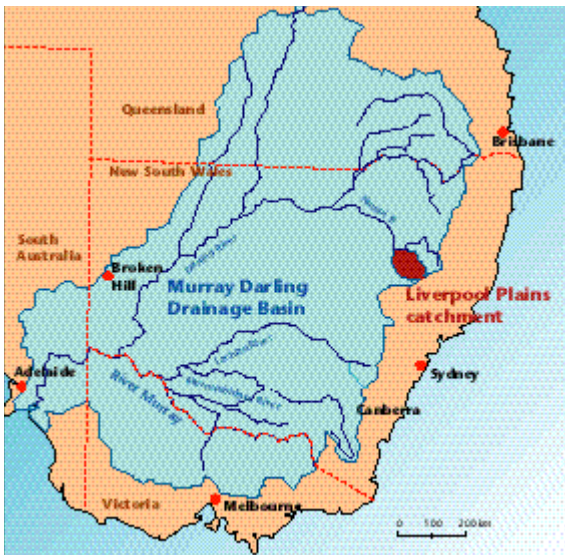
Chairman of the Pine Ridge Landcare Group, Ian Carter, lives at Connamara, a cropping and cattle-grazing property that stretches south-east of the CSIRO well occupied by Froggo and – as we later discovered – Froggo's family.

Carter believes the salinisation probably started accelerating in the '60s, but people believed it was a hard clay pan. Others in the group can't remember a time when there weren't unproductive patches on their properties.

'When a salinity officer was appointed in the early '90s at Gunnedah (80 km north-west) it caused a controversy,' Carter says. 'But there's been a huge swing in attitude since then.'

He now talks in positive terms about saline groundwater. 'In an arid continent, it's an asset to have a rising water table,' he says. 'Even though it's saline, we should use it to benefit. It's a matter of managing soil and water to use the water and counteract salt.'

Land-use strategies aimed at achieving these goals are outlined in the Yarramanbah/Pump Station Creek



Catchment Management Plan, produced last year by the Landcare group and the NSW Department of Land and Water Conservation. The plan classifies the sub-catchment into separate units on the basis of slope, terrain, soils, electromagnetic survey results and land-degradation issues. Management recommendations relate to each unit's characteristics.

An example is the alluvial plains, where saline water discharges to the surface, mainly in patches of low topography. The aim on this land is to achieve maximum use of water in the soil profile, allowing some leaching of salts during periods if heavy rainfall and flooding.

Short-term crops have been replaced or are rotated with perennial plants – trees, saltbush and lucerne – which transpire year-round and develop deeper root systems.

In a 15-ha paddock fronting Cattle Lane, 35 000 silver-grey saltbush plants (*Atriplex nummularia*) are growing as high as Ian Carter's shoulder. 'The sandy ridge above this paddock was cleared for cropping in the 1940s,' Carter says. 'We grew wheat on it during the '50s and '60s, but it progressively became useless. It's a local example of what's happening on a broader scale.'

In trials comparing saltbush with various pasture grasses, all but the saltbush became waterlogged. 'Five years ago

Below: A sorghum crop thrives above a highly-saline watertable at Ian Carter's Pine Ridge property, Connamara.

Inset: Ian Carter has planted saltbush in a nearby salt-affected paddock. 'Now there's no water-logging, and we're starting to get grasses and herbage growing there too,' he says.

Alan Grogan/Works Publishing

we planted saltbush and it has turned the paddock right around, into a productive part of the farm,' Carter says. 'Without it, given the dry season, we would have had to sell the cattle. We'll never crop this paddock again.'

Another perennial being assessed for its potential to increase water use is tea tree. Secretary of the Pine Ridge Landcare Group, Prue Lee, and her husband, Nick, are growing 6 ha of tea tree (*Melaleuca linariifolia*) on their property, Bindaree. The trees, which can be coppiced for oil extraction, were planted two years ago in a paddock prone to waterlogging. But under the recent dry conditions, their progress has been slow.

In areas where the groundwater is less saline or deeper, annual cropping is rotated with a three-year perennial pasture phase. Lucerne pasture is being used because its deep tap roots dry the soil profile after the cropping phase. Lucerne can be either grazed, or baled for hay, and it fixes nitrogen, a nutrient in which local soils are deficient.

Perennials are also being planted higher up in the sub-catchment. Trees by the thousand are reappearing, placed strategically on hills, slopes and ridges thought to contribute to groundwater recharge, and in a trial agroforestry plantation at Paringa, a property owned by the Cudmore family.

Two years ago, in a sloping 12 ha paddock overlooking the floodplain, the Cudmores planted 10 000 trees: a selection of pines and eucalypts including yellow box, ironbark and red gum. The paddock used to be cropped with wheat, but had regressed to plains grass following a fall in wheat yields. A nearby paddock is earmarked for planting with 4000 of the fodder tree, tagasaste.

Hand in hand with perennial plantings at Pine Ridge has been a land-use change of greater proportions: a switch from conventional tillage to zero-till, opportunity cropping. Since cropping began in the district 50 years ago, paddocks have been left to fallow for as long as 18 months between cropping phases, enabling the soil profile to become saturated, and cultivation after cultivation to curb recalcitrant weeds.

The combination of cultivation and long-fallows compacted the soil, destroying its structure and microbiology and increased recharge to the groundwater table. 'We were adding to the water table all the time,' Carter says. 'It took a while, but eventually it got us into trouble.'

Under the new farming system, stubbles are sacred. Crops are planted more frequently, directly into the previous crop's stubble, using flexible rotations that minimise weed and disease risk, and make optimum use of moisture conditions. Potential rotations under zero-till roll off practised tongues like mantras: sorghum, sunflowers, sorghum, sorghum, wheat sorghum . . .

To the uninitiated, it all sounds highly complex. The basic tenet, however, is to recognise and respond to each 'planting window'; when conditions match predetermined requirements for sowing a particular crop – sow it.

'If we get a lot of rain in the next six weeks, we'll put in barley because there's enough moisture,' Carter says. 'If not, we'll wait and plant a summer crop. We now get two goes at everything.' (It did rain, and 500 ha of barley was planted into the sorghum stubble harvested in March-April this year.)

The aim of zero tillage, is to have all machinery – planter, spray rig and header – the same width and wheel spacing, and to drive in the same wheel tracks every time. This technique, known as 'tram-tracking', confines the area of soil compaction.

Parked outside Carter's shed is the heart of his zero-till enterprise, a gleaming red planter, custom-made to sow (and fertilise) summer and winter crops, straight into stubbles on clay-based soils. Its maker, Chris Holland, of Rogro Machinery at nearby Spring Ridge, has been producing two a month, but can't satisfy demand. They've gone to farmers from Queensland to Victoria, but half have remained on the Liverpool Plains.

After 10 years of zero-till, Ian Carter sees obvious benefits. He demonstrates by digging 15 cm beneath a sorghum stubble and scooping a handful of black earth. After a rainless February and March, cracks are apparent on the soil surface, but the black handful is doughy.

'It's been the biggest change in agriculture in 50 years,' Carter says. 'But compared to any other change in farming, zero-till has been readily adopted. We used to

Charles Cudmore with his family's new zero-till planter. Like other landholders at Pine Ridge, the Cudmores have made the change to opportunity cropping, a system designed to improve soil condition and water-use efficiency.

think the paddocks needed a good working – needed to look nice. Now they look really rough, but we're actually looking after them.

'Keeping stubble on the soil is just like mulching a garden. There's moisture in the soil now that wouldn't be there if it was tilled, and there's also a lot more life, including earthworms and fungi. Our per hectare yields have risen, and we've improved our water-use efficiency. I think zero-till and opportunity cropping are a critical part of salinity management.'

Carter's neighbours agree on the production benefits of zero till. Improvements in soils and yields are evident. As for the long-term impact of this and other land-use changes on salinisation rates, it's too early to tell. A monitoring network is in place to pick up trends in groundwater and salinity levels, but these may take 10-30 years to emerge.

In forging ahead with land-use change, the people of Pine Ridge have taken a risk. A mountain of scientific advice is available relating to causes, consequences and local treatments for salinity, but few guaranteed solutions exist.

The research is costly, complex and long-term. Variations in the physical characteristics of catchments mean there can be no universal remedy, and the sluggishness with which hydrological systems respond to change limits the potential of experimentation.

Prue Lee with tea trees planted two years ago on her Pine Ridge property. The trees can be coppiced for oil extraction.

An even greater stumbling block, however, is the need for land-use change, in some cases radical change, to be prescribed and adopted at a regional scale, such as across the entire Liverpool Plains. Broad-scale adoption is vital, because actions in one part of the catchment are bound to have physical and economic impacts elsewhere.

An obvious hydrological link between Pine Ridge and the Liverpool Ranges is illustrated graphically during periods of heavy rain. Older residents in the district remember it taking three to four weeks for, say, 75-150 mm of rain falling 30 km away to reach their properties. Much of the

Sharing the cost of change

Since its formation in 1992, the Liverpool Plains Land Management Committee has supported research aimed at developing catchment-scale strategies for managing dryland salinity, including projects of the National Dryland Salinity Program. As phase one of the national program draws to a close, the committee now has the task of putting the program's research outcomes to work.

Jim McDonald, a Liverpool Plains landholder and former and inaugural chairperson (for five years) of the Land Management Committee, has been wrestling with that challenge for the past two years. McDonald is the leader of the group's research sub-committee, and heads a project investigating ways of creating an environment in which individual landholders will commit to land-use change.

'We have many many years of biophysical research behind us,' McDonald says. 'Our main goal now must be to implement it, but there is an understandable level of hesitancy among many farmers to change practices.'

Salinity management recommendations for the Liverpool Plains will identify the best mix of land uses to balance regional environmental and economic objectives. A consequence might be that some landholders are asked to make costly changes, such as broad-scale tree-planting, for the benefit of landholders elsewhere in the catchment. Or they might be expected to change for the good of the wider community, such as to protect water quality in the Murray-Darling, or to reduce damage to infrastructure caused by flooding.

McDonald is optimistic that landholders will embrace environmental principles in their management practices, but only if they are supported by appropriate incentives. He recognises the need for incentives to be accompanied by a set of standards for farming practice against which compliance with environmental principles could be gauged.

'I was once asked why farmers shouldn't have the same responsibilities as manufacturers in regard to the pollution leaving their land (chemicals, drainage water, soil erosion, nutrients),' McDonald says. 'The question is a fair one, and efforts are being made to address it by the Murray Darling Basin Commission Community Advisory Committee.'

McDonald says the committee has developed a set of cost-sharing principles designed to help agriculture achieve ecologically sustainable development, possibly over some 15 years. The principles attempt to place roles and responsibilities on landholders, communities and governments during this transition period. They address issues such as determining whether individual producers should be penalised for pollution and when community action would qualify for subsidisation.

'Eventually the community will decide that if you own land, you're responsible,' McDonald says. 'But clearly there are public benefits that will accrue from the private work of landholders, such as clean water, maintenance of land values, income production, and the reduction of off-farm effects.

'Many current farming practices are based on past government policy and knowledge, therefore governments bear some responsibility to help people to change again. We need government help to get industry involvement.'

Jim McDonald: 'Clearly there are public benefits that will accrue from the private work of landholders.'

Above: Water that used to be captured by vegetation high up in the catchment now contributes to flooding on the plains.

Right: Irrigation is being considered as a means of relieving pressure on the local groundwater table, but the effects of such a practice have not been investigated.

water infiltrated along the way and floods were seldom seen. But these days the water takes only eight hours to arrive, eroding soils, recharging aquifers, drowning crops – and probably dispensing Froggos – along the way.

Members of the Pine Ridge Landcare Group have tried, with limited success, to encourage landholders from higher up in the Liverpool Plains catchment to investigate and commit to land-use change. But the incentive to change farming practices is minimal when most of the benefits are perceived to be off-site.

By the same token, land use at Pine Ridge may affect others. For example, irrigation of lucerne and trees using groundwater from the catchment's deeper freshwater aquifer could affect groundwaters in adjoining catchments.

When the National Dryland Salinity Program releases management recommendations for the Liverpool Plains next year, will they agree or conflict with changes already made at Yarramanbah/Pump Station Creek?

Will they have sown enough pasture, or planted enough trees? Will it emerge that geological factors beyond the landholders' control have a significant impact on local groundwater levels? Will they need to look harder at saltland agronomy? From a regional perspective, will it be considered cost-effective to invest limited resources in areas of severe salinisation?

Whatever the recommendations, landholders such as those at Pine Ridge will be ready to respond. The challenge for the Liverpool Plains community lies in creating an environment in which others will follow their lead.

The economics of action

A major obstacle to managing salinity at a catchment scale is the existence of externalities: agents that cause a problem, but fail to bear the full cost of its consequences.

Externalities are commonly associated with agricultural activities because as small proportions of landscapes, regions and catchments, farms are embedded in broad-scale environmental processes. Human-induced soil salinisation is a classic example of an externality problem because the land-use activities of uphill landholders can lead to groundwater rises and the mobilisation of salts downstream.

Under present property rights arrangements, landholders responsible for salinisation have no market-incentive to change their practices. Communities may decide the problem is serious enough to offer publicly-funded incentives, but first must consider how big the carrots should be, and where they should be dangled. The process of making these decisions involves internalising the externalities.

Dr Romy Greiner, an ecological economist at CSIRO Wildlife and Ecology in Canberra, has been working on this task for three years. She has developed a modelling framework for analysing biophysical and economic components of salinity management and applied it to the Liverpool Plains catchment in northern New South Wales.

'Once biophysical approaches to salinity management have been developed, the next step is to look at the problem from an economic perspective,' Greiner says. 'This means investigating if and where salinity control is worthwhile, who should bear the costs, and what kind of incentives/policy mechanisms could be employed to encourage landholders to engage in catchment management activities.'

Greiner's model internalises the external effects associated with dryland salinity by treating the whole catchment as a single management unit. It draws on the latest knowledge of hydrology, soils, climate, agriculture, farm management and economics to create the most profitable pattern of land use across the catchment and over time.

Three key messages have emerged from Greiner's modelling. First, the management of groundwater tables and dryland salinity makes economic sense. Secondly, substantial changes in land use are needed to stabilise the salinised area in the Liverpool Plains. Thirdly, these changes have to be implemented quickly (within 10 years) for maximum effectiveness.

Next year, Greiner's framework will be applied to the results of a project updating knowledge of Liverpool Plains hydrology. Outcomes of this analysis will underpin the evaluation of financial and other impediments to land-use change. Further economic research is likely to investigate policy instruments for integrated catchment management and salinity control.