By nature, agriculture has its limits

David Cudmore answers my question with conviction. 'What we need is a high-yielding perennial wheat, and a good summer pasture grass that grows underwater in hot conditions.'

Cudmore, his wife, Wendy, and sons Sandy and Charles, have a property at Pine Ridge on the Liverpool Plains in New South Wales. He and his sons, and their five dogs, had just climbed out of the ute after a tour of the farm. We'd studied tree plantations, lucerne pastures, and paddocks cosseted in stubble; efforts to hold saline groundwater at bay.

The next day, David Cudmore would travel to Wagga Wagga, for a seminar on agriculture for saline land. I'd asked him what message he'd take to the scientists.

'Lucerne is not ideal for us because it doesn't like wet feet,' he said. 'We've tried other pasture grasses, but they tend to "cook" during summer in the black soils.'

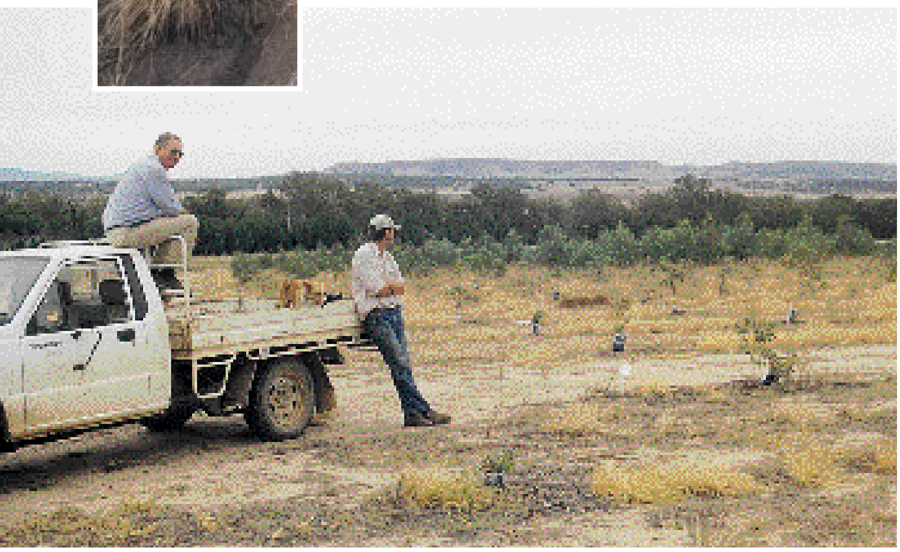
Cudmore's subsequent remark about perennial wheat had been made with a chuckle, but really it made perfect sense.

Before being cleared for cropping, his low-lying land was covered with plains grass (*Stipa aristiglumis*), a summer-active native perennial. The grassland ecosystem had existed there for thousands of years, in an area prone to periodic salinisation. It had even survived half a century of grazing by sheep. Surely it offered clues about the possibilities and limitations facing sustainable agriculture in such a landscape?

The idea of borrowing from natural ecosystems when designing agriculture, or 'functional ecosystem mimicry', was discussed by scientists at a conference in Western Australia last September. They exchanged stark examples of agriculture failing because it couldn't perform the functions of natural systems. They also explored the value of learning from natural ecosystems in attempts to make agriculture more sustainable.

A pioneer of the mimicry concept is Wes Jackson, author and co-founder of the privately-funded Land Institute, at Kansas in the United States. Jackson believes the best agriculture for any region is that which best mimics the region's natural ecosystems.

David and Sandy Cudmore survey a woodlot planted to increase water use and improve productivity in a degraded paddock. The Cudmores have also planted lucerne to reduce drainage to the watertable. What they'd really like to see, however, is a high-yielding crop or pasture species that mimics the hydrological function of *Stipa aristiglumis*, the deep-rooted plains grass that once swathed the Liverpool Plains.



In keeping with this philosophy, research at the institute has centred on changing agriculture on the Great Plains from annual monocultures of corn and wheat, to prairie-like grainfields, or perennial seed-producing polycultures.

The idea is that grains could be harvested annually, but resown only once every three, five or even 10 years. Potential benefits would include reduced erosion and soil loss; less need for fertiliser, tillage, chemical, irrigation and fossil fuel; maximum water use efficiency; and the return to production of marginal land.

Before clearing, the Great Plains supported warm and cool-season grasses, legumes, and sunflower species. The institute now has under trial an analog of each of these plant types. Together they form a rough mimic of the prairie's native vegetative structure. The actual transition to polyculture on the Great Plains is estimated, at best, to be 15 to 25 years away, and depends on US Department of Agriculture support.

Were similar perennials available to mimic grasslands of the Liverpool Plains, David Cudmore and his neighbours would no doubt be lining up to try them. Australian plant breeders have yet to mimic Jackson's zeal for polyculture, but the philosophy is being applied by scientists in assessing strategies for salinity control.

In southern Australia, replacement of natural ecosystems with conventional agriculture has resulted in large-scale disruption of the natural water cycle. Enhanced groundwater recharge and rising groundwater tables, surplus soil moisture during the growing season, the resurgence of deep aquifers, mobilisation of stored salts, and increased discharge of water and salt to streams. These changes stem from the inability of conventional agricultural systems to mimic the function of the original vegetation.

Dr Tom Hatton is an ecohydrologist based at CSIRO Land and Water in Perth. He says the complexity and diversity of landscapes across Australia prone to salinisation and in need of remediation, challenges the boundaries of experimental research.

'Agronomic and agroforestry trials offer only a local, short-term glimpse of the functional role played by individual components of complex, managed ecosystems,' he says. 'Results generated by this piecemeal approach cannot necessarily be extrapolated to other sites and timescales. It's a case of the tail wagging the dog.'

Hatton says the economic, social and political constraints relating to a wide variety of salinity remediation strategies are well understood. The chances of actually achieving the desired environmental, or ecohydrological outcome, however, are comparatively vague. He says the key to defining the limitations of salinity control measures lies in complementing experimental research with an understanding of how natural ecosystems function.

For example, extensive efforts are being made to increase evaporation from agricultural plants in an attempt

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to minimise groundwater recharge, by selecting tree species for high water use, and improving water use of crops and pastures. Hatton suggests that the natural limits to this approach are apparent from studies of evaporation by native plant communities in Australian catchments.

Ecohydrological studies show that natural evergreen ecosystems in those Australian environments with salinisation potential maintain a remarkably similar leaf area for a given amount of rainfall. In fact, just enough leaf area to minimise runoff and groundwater recharge. 'If revegetated areas operate similarly, we have a gauge by which we can estimate how hydrologically effective these plantations are in reducing salinity,' Hatton says.

'This knowledge can be used to estimate the effectiveness of tree planting. It also calls into question the large effort going toward assessing differences in plant water use among Australian evergreen species, at least in the absence of constraints other than water.'

Also evident from natural systems are constraints to the relative water-use potential of annual crops. For example, while natives collect water during the rainy season for growth during summer, cool-season or crop grasses grow only while water is available in the upper metre or less of soil.

'An understanding of atmospheric physics shows there is insufficient energy during the growing season of these grasses to evaporate all of the wet season rainfall in most salinity-prone areas, Hatton says. 'Unless we breed or select grasses with the same functional characteristics as the native vegetation, it is unlikely recharge control can be achieved. Should we be investing in better grasses when we know grasses alone never did the job in the first place?

Another important challenge lies in determining the sustainability of production in saline discharge areas. These have always been a feature of the Australian landscape and a variety of natural plant communities are dependent on them, including samphire, saltbush, shrublands, sedgelands, eucalypt and paperbark forests. On the other hand, there are discharge features devoid of vascular plants, such as salt scalds and salt lakes.

Hatton says characterising the ecohydrological niche of such communities – including interactions between evaporation, transpiration, rainfall, flooding and groundwater movements – is an efficient way of predicting the productivity of saline sites. This is in stark contrast to agronomic trials in which experiments assess local short-term production without generating the means to extrapolate to other saline areas.

'The best example of this approach in Australia is the research on the *Eucalyptus camaldulensis* and *E. largiflorens* woodlands on the Chowilla floodplain of the Murray River in South Australia,' Hatton says.

'In this study, the natural dynamics of salt, groundwater and flooding were related to woodland health, enabling development of a model to simulate the response of the woodlands to changing hydrology and climate. This has provided the means to predict the health of woodlands at other floodplain sites.'

CSIRO and LWRRDC are supporting further research and development in this area under the Redesigning Australian Plant Production Systems Program. The aim of this program is to develop environmentally sustainable and potentially novel agricultural systems in harmony with the Australian environment.

Hatton has been working with Dr Bob Nulsen of Agriculture Western Australia to determine how functional ecosystem mimicry might be achieved with respect to water cycling in southern Australian agriculture. Their conclusions are grim.

'While profitable agroforestry options exist in some environments, the scale of the tree planting required to significantly restore the original water balance across southern Australia is daunting,' they say. 'Hydrologically effective and economically attractive options do not yet exist for the vast proportion of southern Australia's agricultural region.'

Hatton and Nulsen say it is unlikely that the full complement of hydrological functions can ever be restored with revegetation, even using the original genetic material. Some changes to hydraulic and hydrochemical characteristics of the system may be irreversible.

'The most pessimistic assessment suggests that Australia's southern landscape will not be renewed until the next geologic orogeny (period of upheaval) or a large change in climate. Nevertheless, there is an ethical compulsion to bring to our agriculture as much of the original hydrologic function as possible.'