Land use revolution needed to halt salinity spread

Dryland salinity is a serious problem affecting many parts of Australia. Current farming systems, even when implemented with best practice, will not control salinity. This article looks at some of the land use options which may be available to farmers to help combat salinity.

Farmers will need to adopt a suite of innovative land uses better matched to their climate and soil type to halt the spread of dryland salinity.

According to CSIRO research, few current farming systems can significantly reduce recharge rates to levels similar to native vegetation.

A revolution in land use is necessary to slow the encroachment of salinity.

About 5.7 million hectares in Australia are now at risk or already affected by dryland salinity and this figure could increase to 17 million hectares during the next 50 years.

Research shows there is no single land use option which is capable of controlling salinity. New ways of managing agricultural land are needed.

Some options suggested include commercially viable tree production systems or new farming systems using novel mixes of annual and perennial plants, companion plantings and rotations.

In the future, new varieties of cereals, pulses, oilseeds and forages will be selected or bred for characteristics which reduce deep drainage and nitrogen leakage.

CSIRO also hopes land assessment tools will be refined to identify the best locations for agroforestry and high-value crops. New tools also will be developed for farmers to monitor leakage and change land use accordingly.

The spread of salinity

Most of Australia’s native vegetation comprises trees, woody shrubs and perennial grasses.

Perennial vegetation has deep, dense, root systems. These minimise the amount of water that leaks past the root zone to ground water.

Studies have shown the leakage rate in areas of native vegetation was between 1–5 millimetres per year.

But large-scale clearing of native vegetation and its replacement with annual crops and pastures have significantly increased water leakage beneath the root zone (15–150mm/year for cultivated grasses and crops).

The amount of water leaking into the groundwater system depends on the climate (particularly rainfall distribution and amount), the depth, water storage capacity, and permeability of soils and subsoil and vegetation characteristics.

Not all water leaking beyond the root zone ends up in ground water. Water moves laterally through the soils to drain into surface streams. Leakage also can occur from the base of streams into ground water.

The symptoms of dryland salinity include sick or dying trees, declining vegetation, salt-tolerant volunteer (weed-like) species such as sea barley grass and spiny rush, bare salty patches and saline pools in creek beds.

For land use options to be effective, they must achieve leakage rates similar to native vegetation and occupy about 40 per cent of a catchment or landscape. This requires a revolution in land use.

CSIRO is investigating some of the current land use options and future prospects for managing dryland salinity.

Annual cropping proves ineffective

Annual cropping is the preferred economic option for many farmers but research in the Murray–Darling Basin (covering Queensland, New South Wales, Victoria and South Australia) shows it is ineffective in achieving the required leakage targets.

Estimates of average annual leakage for a wheat cropping system in the Basin range from about 1mm to more than 200mm.

Simulations show that high-input farming has a large effect on yield but not on drainage. Doubling nitrogen fertiliser rates from 40 kilograms per hectare to 80kg/ha increased yield by 20–40% but only reduced annual leakage by about 25mm.

The research highlighted the influence of winter-dominant rainfall on leakage. As winter dominance increases, so does the leakage associated with annual cropping. This is because more rainfall occurs in the cooler months, when potential water use by crops and loss via soil evaporation is reduced.

Although leakage targets vary depending on the catchment or landscape, they need to be significantly less than 20mm each year.

Based on the studies, annual cropping systems fall well below acceptable leakage targets.

Cropping may need to be confined to soils with high water-holding capacity and focus on summer crops or perennial pastures in rotations.

Opportunity crops increase water use

One option to increase water use by annual crops is to sow crops opportunistically during winter and summer when rainfall and soil water conditions allow.

This is useful, particularly in areas where summer rainfall is more significant.

In the northern part of the Murray–Darling Basin, soils with high water-holding capacity coincide with sufficient summer rain to allow cropping at almost any time of the year.

CSIRO research showed drainage from a catchment under annual crops was nearly six times higher compared with native vegetation.

Opportunity cropping yields a leakage volume less than twice that of native vegetation. But this will vary depending on soil type.
Phase and companion cropping

The greatest obstacle to controlling leakage in annual cropping systems is season-to-season rainfall variability.

Average leakage may be 50mm/year but developing farming systems, which use an extra 50mm/year would not solve the problem.

The wetter-than-average years contribute most to drainage and any sustainable system must have the capacity to deal with these years. This can only be achieved using perennials.

Annual crops can be made to behave more like perennials using phase farming or companion farming (combining and alternating perennials with annual crops).

In phase farming, a deep-rooted perennial like lucerne can create a dry soil buffer of more than 200mm. This means it can prevent leakage most years and also protect subsequent crops in a rotation.

The introduction of a perennial deep-rooted pasture phase, which can dry the soil to a three-metre depth in a cropping rotation, can reduce leakage by more than 70%.

Companion farming is a new concept in which annual cereals are oversown into a perennial pasture system, ideally one which has a strong degree of winter and spring dormancy. The perennial pastures could be native grasslands or deep-rooted legumes such as lucerne.

These systems have been studied in calibrated simulation models and appear to be potentially more effective than phase farming in controlling leakage, with at least the same grain-yield production possibilities.

But there may be a trade-off in production through competition for water and problems with obtaining a clean harvest. This option could be implemented during the short term (3–5 years).

New crop and pasture varieties

Current crop and forage species have been bred for high yield and tolerance to diseases and pests. Little attention has been given to their ability to use water, nitrogen and impact on dryland salinity.

Immediate opportunities lie in longer season varieties and species. Good prospects exist to develop winter wheats and canola varieties, which can be sown as early as February, if rainfall conditions allow, and grazed during May. These crops then regrow to produce a grain yield during the normal spring–early summer period.

In the long term, conventional plant breeding and biotechnology could be used to develop new plants with more extensive root systems and a better capacity to use water from the soil profile. Other traits being investigated include enhanced early vigour, waterlogging tolerance and disease resistance.

High-rainfall tree products

Forestry for sawlogs and pulpwood is a potentially valuable land use where annual rainfall is more than 800mm. Where rainfall is below this limit, forestry is more difficult.

Although planting trees can improve water quality and reduce leakage, water run-off would decline due to increased evapotranspiration by the trees.

In catchments which currently yield high-quality water, the water value could be more than the timber value.

One estimate suggests the decline in average annual run-off after planting is up to 220mm for eucalypts and 290mm for pines, where annual rainfall is 1000mm.

Further research is required to manage this trade-off and forestry needs to be implemented carefully in catchments with heavily allocated flows such as the Murray–Darling Basin.

Low-rainfall forestry systems

Developing low-rainfall tree products is potentially the most relevant, effective and robust land use option for managing salinity.

But with the exception of a few niche industries, low-rainfall forestry does not exist in a commercially viable form.
The major obstacle is finding markets of sufficient size and value to drive reforestation and the use of native plants at the necessary scale. Research is essential to develop new markets for trees to produce fruits, nuts, oils, pharmaceuticals, bush foods and forestry products such as speciality timbers, charcoal, and biomass energy.

**Tree–crop mix reduces leakage**

In the absence of forestry which is as profitable as cropping, the careful location and arrangement of trees can increase their water access and growth rates and minimise the displacement of valuable crops.

But mixing trees and crops introduces the problem of competition for light, water and nutrients. Tree–crop combinations will only be profitable if the value of tree products and any benefits from shelter exceed the value of the displaced crops and decline in crop yield through competition.

Most studies have shown that the increase in crop yield resulting from nearby shelter hardly compensates for the loss of crops closer to a row of trees. So, situations where drainage is reduced and profitability is increased are rare.

But tree–crop mixtures can be a better way of reaching a target reduction in leakage than having part of a catchment in plantation and the rest in crop.

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**Perennial pasture limitations**

Perennial grass pastures are capable of using higher rates of water than trees in the short term (days) but cannot match tree performance in the medium to long term. This is because perennial plants seldom have roots below a two-metre depth while tree roots frequently reach below a depth of 6m.

Although they are an improvement on annual pastures, perennial pastures cannot meet recharge targets where rainfall is more than 600mm and is winter-dominant.

Acid subsoils also limit the distribution and performance of the most favourable species of perennial pastures and heavy grazing can significantly reduce water use. There is evidence that native grasses have higher surface run-off than introduced grasses and can reduce leakage beneath the root zone.

**Engineering options**

Engineering options include simple surface water management measures such as banks and drains or more expensive measures such as deep drains, sub-surface drains, pumps, interception and diversion systems.

Managing surface water to control flows for erosion, waterlogging and harvesting water on farms has been common in many areas. With careful planning this offers opportunities for removing surface water before it can infiltrate and contribute to recharge.

But the costs of establishing and operating these technologies are high and are only applicable in intensive farming or where it is necessary and economically viable to extract ground water for industry development.

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