Wetting up the soil at one of the NSW Agriculture field sites, in preparation for measuring soil properties.

Seeking clues to watertight cropping

Dr Hamish Cresswell and his colleagues must have harvested enough fodder in the past three years to fatten all the domestic livestock in Australia. At least they would have if all their crops and pastures had been grown in paddocks rather than computers.

Cresswell, a CSIRO soil physicist, is coordinating a team of scientists involved in deep drainage research for the National Dryland Salinity Program. They hail from CSIRO Tropical Agriculture, CSIRO Land and Water, NSW Agriculture, NSW Land and Water Conservation, the Queensland Department of Natural Resources, and the Victorian Department of Conservation and Natural Resources.

The team is using a modelling framework called APSIM (Agricultural Production Systems Simulator) to find out how much water drains beneath a range of cropping and pasture systems at a paddock scale. The framework was developed at the Agricultural Production Systems Research Unit in Toowoomba and one of its main architects was cropping systems scientist Dr Brian Keating.

APSIM's agronomic prowess is awesome. It grows sorghum, cotton, sunflowers, maize, barley, cowpeas, peanuts, sugarcane, stylo, lucerne, and tropical and subtropical grasses, in a range of soil, water, nutrient and climate conditions. Under each of these scenarios, cultural inputs such as fallow length, tillage and crop rotations can be varied, just as a farmer does in real paddocks.

For each kind of production system, APSIM can predict many outcomes, including deep drainage and crop yields. This allows the associated costs and benefits, both economic and environmental, to be assessed. By repeating each production phase, cumulative effects over many years can also be calculated.

Knowledge gleaned from these model runs will help farmers in areas of rising groundwater tables across Australia to make land-use decisions that maximise production, but minimise leakage to groundwater tables. It will also help other scientists involved in groundwater modelling at a catchment scale.

Before the team will stake its reputation on APSIM, however, the framework is being subjected to a rigorous program of validation and development. This involves testing its predictions against the results of field trials at Pine Ridge in the Liverpool Plains in northern NSW.

The trial sites were established on private properties in 1994-95, one on heavy black clays and another on lighter red soils. They are the focus of a major research project by NSW Agriculture's Tamworth Centre for Crop Improvement, headed by research agronomist Rick Young.

Treatments under evaluation include long fallow wheat/sorghum, continuous winter cereal cropping, opportunity cropping, (a system where additional crops are planted if there is sufficient stored water at sowing time) and native and introduced perennial pastures.

'What we're doing is local best practice agronomic management and the evaluation of opportunity cropping systems,' Young says. 'We're pushing the opportunity cropping system as hard as we can: putting in a lot of crops

Alan Grogan/Works Publishing

Measurements taken at the NSW Agriculture field sites include temperature, rainfall, humidity, grain yields, evaporation rates, runoff and soil chemistry.

to maximise water use. The aim is to quantify the water use and deep drainage in each of the cropping systems.'

Soil water content is measured at the sites from the surface to three, and sometimes six, metres below the ground to infer crop water use, root depth and infiltration. Other measurements include temperature, rainfall, humidity, biomass production, grain yields, crop residues, groundcover, evaporation rates, runoff and soil chemistry.

So far, the trial results have shown:

- lucerne is effective in drying out the soil profile by removing soil water down to 3 m in a 12-month stand;
- native grasses such as Wallaby grass and Bambatsi panic also reduce deep drainage, but not to the same extent; and
- long-fallow wheat-sorghum rotations produce less total grain production than intensive opportunity cropping systems, and carry a higher risk of runoff and deep drainage.

Data collected from the trial sites are being used to test the predictions for similar production systems generated by APSIM, enabling the model to be fine-tuned. 'Once we're happy with its accuracy, we'll run the model over periods of 50 years of historical climate data, for example, to see what's happening in the long term,' Cresswell says.

'We expect to see that opportunity cropping and perennials use more water and result in less drainage than fallowing, but it's important to confirm and quantify this difference. If we don't go through robust economic analysis of different systems, we won't get farmers to change. If we present only part of the solution, then it won't be adopted.'

Cresswell says climate and soils can have a big effect on deep drainage, meaning the answer on one farm can be quite different on another. For example, water generally moves more slowly in soils with fine clay particles, but this depends on how well the soil is structured. Soils that are not ploughed are more likely to be well aggregated, retaining pore spaces through which water and air can move.

Also, in summer rainfall zones such as the Liverpool Plains, the chances of reducing deep drainage through land-use change are better than in regions such as southern Victoria, because significantly more water can be transpired during a summer cropping phase.

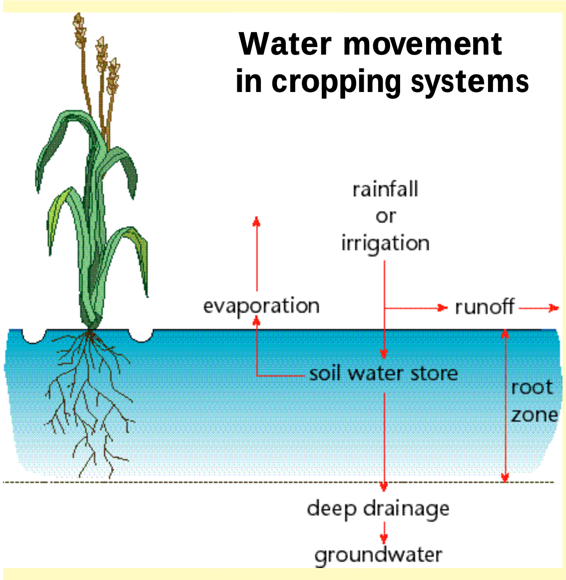
Improving the portability of the APSIM framework, both across the Liverpool Plains, and in other catchments, is a central component of the project. 'We use different climate and soil information together with the model to extrapolate over different site conditions,' Cresswell says. 'Then we can achieve drainage predictions across whole catchments or parts of catchments where we might not have agronomic trial sites.'

The research team hopes that APSIM will increasingly be consulted directly by farmers, perhaps through local agronomists trained in its use. Results of the modelling and fieldwork will also help determine whether changing agricultural management will make a significant difference to groundwater tables on a catchment scale.

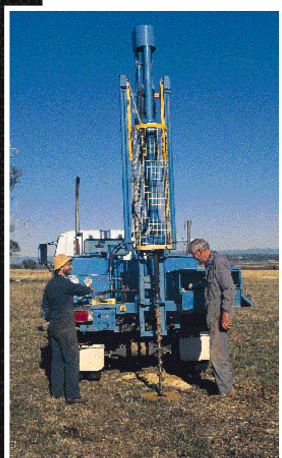
'Paddock scale modelling doesn't tell you where the water will end up in a catchment, but it can contribute,' Cresswell says. 'We can take the results from our bit of dirt to the catchment modellers, who can help calculate the impact of adoption of alternative land-use practices on a broad scale.

'We're at a challenging frontier in methodology that requires both catchment and paddock models. The breakthrough we're seeking is to put the two together.'

The Agricultural Production Systems Research Unit is a collaborative venture between CSIRO Tropical Agriculture, the Queensland Department of Primary Industry and the Department of Natural Resources.



Deep drainage is the water that 'leaks' beyond the root zone. It is usually the smallest component of the soil-water balance and is relatively difficult to determine. Deep drainage can contribute to groundwater rise, so its reduction is important for salinity control.



Left: Hydrologic measurements were taken to help determine how quickly water flows beyond crop roots.

Below: Drilling holes for the installation of groundwater monitoring equipment.