How Nature protects the soil

In this Year and Decade of Land Care, landholders will be encouraged to plant more trees for the many benefits they can bring to our tired soil. Preventing salinity is one (see 'Restoring the Murray–Darling Basin' in this issue); preventing erosion is another. But the presence of a tree doesn't automatically mean that the soil will be protected.

Certainly, a tree can act as a windbreak, inhibiting wind-induced erosion, and its large root mass can help bind soil particles together. However, in some circumstances, the way it intercepts and changes the erosive potential of raindrops can mean that it causes more damage than it prevents.

According to Dr John Moss and Mr Tom Green, of the CSIRO Division of Soils, who have been investigating the way in which raindrops interact with leaves and other parts of plants, whether a tree makes things worse or not depends on its height, its shape, and what grows (or is allowed to accumulate) beneath it.

If you've never examined closely what happens to rain as it falls onto and then off plant leaves, why not have a look?

You will see that small raindrops tend to adhere to a leaf in their entirety, usually spreading sideways before coming to rest. Larger raindrops break up on impact, ejecting some of their water as 'high-velocity impact droplets' and leaving the remainder behind on the leaf.

Some of these impact droplets reach the ground directly. Some adhere to other leaves and twigs that intercept them, kept there by surface tension until enough water accumulates for gravity to start a downward flow. Prostrate plants whose leaves touch the ground, and others like grasses with upright leaves growing from a stem, provide a route for the water to flow to the soil.

But most leaves act like small catchments, collecting water and diverting it to their lowest points — usually the leaf tips — which periodically release large drops. These large 'gravity drops' are released at near-zero velocities and accelerate rapidly, striking either the ground or another plant part lower down.

John Moss and Tom Green have shown that it is when these large drops hit the soil from a height of a metre or more that the trouble begins.

Using a 'rain-tower' to simulate rain, they measured the size of gravity drops falling off the leaves of 28 plant species. The size of the leaves — they ranged between 300 and 21 200 sq. mm — did not affect the drop diameter, which varied from 3·7 to 6·7 mm. Larger leaves merely produced more frequent releases from their tips.

The team found that, compared with most raindrops (which rarely reached 5 mm), gravity drops are large and fit into a narrow diameter range. The scientists arranged for drops of the average gravity-drop diameter, 5·1 mm, to fall from several different heights onto a tray of sand, and recorded the way sand particles were disturbed.

The results showed that where drops are the same size,

Leaves act like small catchments that periodically release large potentially erosive drops.

impact velocity — which, in turn, depends on fall height — determined the extent of erosion they caused. (Large drops reach one-quarter of terminal velocity after falling only 0·3 m and about half by 1·2 m. Terminal velocity is not reached until the fall distance reaches about 13 m.) At the maximum velocity and height used (11·2 m) the gravity drops formed deep craters and moved some sand grains more than a metre.

As the scientists decreased the fall height, craters became shallower and sand movement much less. At about 0·2 m fall height, drops moved few sand grains more than 0·1 m; and no grains moved when drops fell from a height of 0·1 m.

Although the distance they fall determines the drops' velocity, plant height cannot be used to predict their erosive force. This is because — depending on the shape of the plant and its branching habit — many of the drops are re-intercepted as they fall through the canopy.

For example, compared with large gum trees that have shed their lower limbs, conical coniferous trees with branches extending to the ground will continue to re-intercept drops as these move downwards.

John Moss and Tom Green consider that it is more useful to divide plant covers into a series of arbitrary layers (see the table). Most individual plants have elements in two or more of these layers, gravity drops from the higher ones being intercepted by the lower.

In laboratory studies, using drops of known diameter falling onto both stainless steel and sand targets, the researchers found that 'impact droplets' had practically no ability to cause soil erosion. Although these droplets are released from their parent drops at high velocities, they are usually small (90% are in the diameter range 0·1–1·0 mm), and have initial trajectories above the horizontal, allowing them to decelerate before striking the soil at low angles.

In earlier studies Dr Moss had found that, at the same intensity, large raindrops had many times the erosivity of small ones. The 5·1-mm drops moved medium-grade sand at twice the rate of 2·7-mm drops, 225 times faster than 1·27-mm drops, and about 15 000 times faster than 0·81-mm drops. It seems that impact droplets, by converting erosive rainfall into harmless drizzle, are an important soil-conserving mechanism.

Based on his research and other relevant data, John Moss has developed a 'critical disruption curve' that shows the erosive potential of all

The 'layer' from which gravity drops fall to the ground, rather than plant height, determines erosive force.

Drop fall influences soil damage

layer 1: less than 0·3 m

owing to the often high density of plant–ground contacts, gravity-drop yields are usually low

impact velocities are too low to allow significant soil damage

layer 2: 0·3–1·0 m

transition from small to significant gravity-drop erosivity and soil damage

layer 3: 1·0–2·5 m

gravity drops reach high erosivity and achieve marked ability to cause soil damage

layer 4: 2·5–6 m

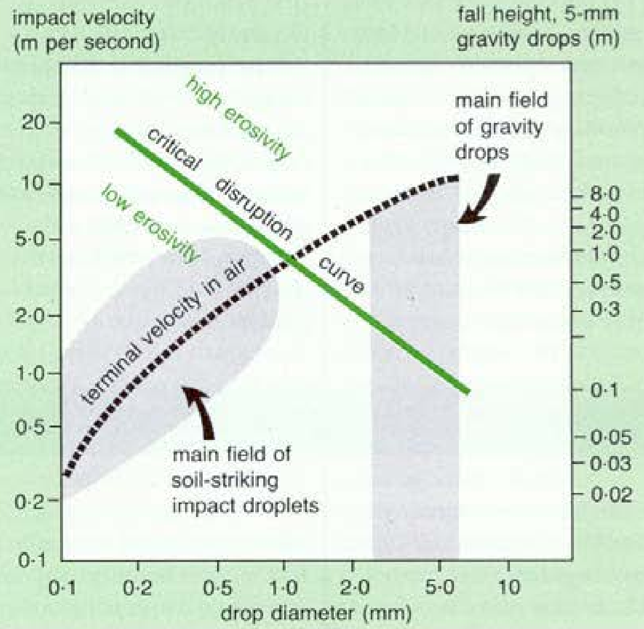
through this layer the ability of gravity drops to cause erosion and soil damage increases, but more slowly than in layer 3

layer 5: greater than 6 m

after 6 m of free fall, gravity drops fall at more than 90% of terminal velocity

hence, above this height, little further increase occurs in ability to cause either soil damage or erosion

Erosive potential of drops



Drops that fit above the 'critical disruption curve' are more erosive than those that fit below it. Vegetation can reduce the erosivity of rain-and gravity drops by converting them to 'impact droplets' or by lowering the height from which they fall.

drops striking the soil surface (see the diagram opposite). Above this curve, drops become rapidly more erosive; below it, erosivity quickly dwindles.

On these criteria, tall plants without leaves close to the ground or without an adequate ground-cover understorey — like old gum trees in an overgrazed paddock — are an erosion hazard. This reinforces the view that experienced graziers have held for many years: a well-grassed paddock gives good soil protection, while the soil beneath isolated trees, denuded of ground cover by stock seeking shelter, is prone to erosion.

On the other hand, clumps of trees and shelterbelts that support a range of plant types and sizes, including ground cover or a layer of decaying leaves and twigs, provide protection against erosion. This is an arrangement that's closer to the 'natural' solution — grasses and multi-tiered forests with litter — for keeping our soils intact.

David Brett

Erosive effects of the large water drops (gravity drops) that fall from plants. A. J. Moss and T. W. Green. *Australian Journal of Soil Research*,1987, **25**, 9–20.

Impact droplets and the protection of soils by plant covers. A.J. Moss. *Australian Journal of Soil Research*, 1989, **27**, 1–16.