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The upper part of this gully is stabilising with good vegetation on its bed. Fencing out the sheep will speed the process and allow the adjacent areas to also revegetate. Photo Roger Charlton.

Managing gullies on wool-producing farms

This fact sheet from the Land, Water & Wool Program summarises information about gullies, their prevention and management, so that woolgrowers can make informed decisions about what to do on their own property.

The Program's Rivers project was established in 2003 in the Yass region of New South Wales with the specific aim of testing and demonstrating options for gully management that growers can consider. Some of the information here has come from that project, but this fact sheet is also applicable to many areas of the tablelands in Queensland, New South Wales and Victoria where sodic* subsoils are easily eroded and gullies are common.

* Soils with high levels of exchangeable sodium and low levels of total salts are called sodic soils.

Left: An actively eroding gully, common in the tablelands of the eastern states.
Photo Samantha Burt.

What is a gully?

Gullies form when surface water flowing over the lower parts of a paddock is able to erode the surface soil, and often subsoil, to cut a channel. The channel may start at only 20–30 centimetres deep, but may become many metres deep over time. Seepage can also be an important mechanism in gully formation. Surface erosion and seepage can occur separately or together. Seepage occurs when water that has infiltrated the topsoil then flows or weeps from the ground, usually lower down a slope. If the subsoil is sodic with poor structure (quite common on the eastern states tablelands), the water can dissolve it and carry it away, forming a shallow depression that causes the topsoil to collapse into the space.

These eroding depressions, if allowed to continue, eventually become incised channels called gullies. They are usually found at the upper end of a drainage (stream or creek) network. They often have steep sides, and may become stabilised by vegetation over time, or remain a source of active erosion. The flow of surface water in gullies is usually intermittent, unless continued seepage is sufficient to provide a base flow within the gully channel itself. Gullies normally connect directly into the stream network, discharging large quantities of sediment and associated nutrients during flow events. The density (length) of gullies varies in different landscapes, but may be up to 1 kilometre of length per square kilometre.

Why are gullies important to woolgrowers?

Gully erosion reduces the amount of productive land, especially in lower areas where deep soils and retained moisture support denser, greener pasture growth after the surrounding hills have dried off in summer. Large gullies limit access to paddocks, and make stock management and mustering more difficult and time consuming. Stock can be lost through accident by falling into deep gullies, injuring themselves and getting stuck. Water quality in streams, creeks and farm dams is degraded by the sediment and nutrients generated by gully erosion, and this can reduce water intake by sheep.

Fencing to exclude stock and help control grazing by feral and native animals is the first step in rehabilitating a large gully such as this.
Photo Gary Caitcheon.

Farm dams may be filled with sediment from gullies and require periodic re-excavation. The accumulation of sediment from gullies within streams may cause more frequent and widespread flooding during high flows, and in peak flows coarse sediment may be deposited on paddocks. The continued extension of an eroding gully may also threaten important farm assets including roads, culverts and bridges.

Why are gullies an important natural resource management issue?

Gully erosion generates large quantities of sediment that degrades water quality and smothers in-stream habitat in situ and downstream (see 'Bogolara' case study overleaf). Neighbours may not be able to take water for domestic use and for stock until the water clears. Storages downstream will lose capacity as they fill with gully sediments, and water treatment costs are increased.

The diversity and extent of stream and river habitats is reduced by high sediment loads with attendant nutrients and other contaminants. High turbidity levels caused by suspended sediment also reduce the abundance of aquatic plants and animals.

How do gullies form?

Erosion of the land by water is a natural phenomenon, and over geologic time has shaped the landscape of mountains, hills, valleys and watercourses that we see today. Gullies are just one aspect of that continuous erosion, but they are often symptoms of a landscape change that leads to loss of the equilibrium established over time between the erosive power of water flows and the resistance offered by vegetation and soils. Such change, for example in rainfall or surface flow pattern or in pasture cover, can lead to a large and rapid erosion event.

Gullies generally form in the lower parts of a landscape where surface flow converges during extreme rainfall events or when the soil is already saturated from earlier rain; in either case, the rate of precipitation exceeds the infiltration rate, so water pools at the surface and begins to flow. The depth and width of the flow and its speed, and hence its erosive power, depend on the size of the catchment area and its slope, as well as the rainfall intensity. A large and steep catchment, and intense rain, will result in large volumes of water converging onto the lower parts of a paddock. Gully erosion due to seepage is also found mainly in the lower parts of the landscape.

Whether this flow is able to erode a new channel within the paddock is determined by the vegetation cover of the soil and whether it can resist the force of the flow (or even better whether it can lay down flat on the soil surface and thereby protect it), and the resistance to erosion of the soil surface. If the vegetative cover if low, and the soil susceptible to erosion, it is likely that the surface protection will be breached and erosion of a channel commence.

Once a channel with bare sides and floor has been formed, erosion can continue from raindrop impact, from dissolution of the sodic subsoil by seepage, and from erosion by further flow within the gully.

Case study

The loaded gully — why better management options are needed

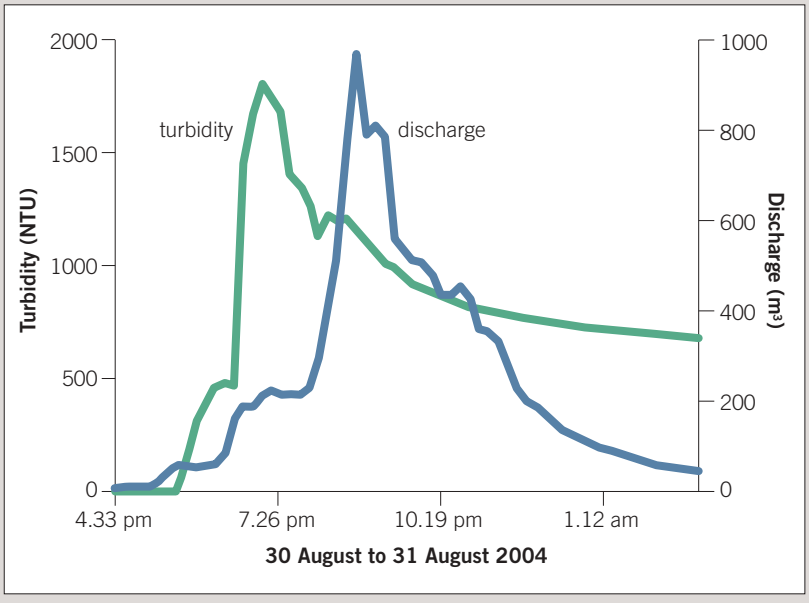
CSIRO research supported by Land, Water & Wool is showing that a 50 millimetre rainfall event can send 60 tonnes of suspended sediment, 15 megalitres of discharge (water flow), 20 kilograms of phosphorus and 75 kilograms of nitrogen through a single farm gully within hours.

Run-off, water quality and turbidity data has been captured by the researchers using sophisticated technical equipment installed on a typical gully in the region, located on the NSW Southern Tablelands property 'Bogolara'. The data is being used by local woolgrowers and researchers to learn about the impact of gullies on water quality downstream, and to develop better management options applicable to the hundreds of similar gullies throughout the tablelands regions.

Monitoring stations like this one have been constructed at the entrance and exit of a large gully on 'Bogolara', so that the effects of management on flow, sediment, and nutrient movement from the gully can be measured over time.
Photo Gary Caitcheon.

Results to date tell an interesting story (see diagram below). Researchers have found that the amount of sediment being released through the gully (that is, the total load rather than the concentration shown in the diagram) does not match the shape of the flow curve, but tends to remain at quite a high constant level. The dominant erosion process at work in the gully during the flow event is scour, and this can continue to loosen and carry away fresh soil from the unprotected gully sides as long as the flow continues.

This helps to explain why such gullies continue to expand in the landscape. Such expansion will keep occurring unless they are stabilised or until the lowered surface reaches a new equilibrium.



The blue line on the graph shows discharge through the gully during the flow event. It was quite a short event, starting at 4.30 pm, peaking at around 8.00 pm and then tailing off around midnight. What is interesting is the green line that shows the concentration of sediment, or the turbidity measurements, peaked before the peak of the flood. This is because when the event starts the rain immediately washes off the loose surface soil from the gully sides and bottom; once this has been washed away the turbidity falls to a lower level.

A large dam has been built near the head of the gully to prevent further erosion of the bed lower down, and to provide a valuable farm asset. Photo Fleur Flanery.

The research project has gone on to trial a range of different treatment options, including a large dam at the head of the gully, side contour banks, and a large program of revegetation. For further information about the project contact Fleur Flanery. Tel: 0408 627 774.

Local woolgrowers, agency staff and Land, Water & Wool members have combined to plan, implement and monitor the 'Bogolara' project. Photo Fleur Flanery.

Far left: A typical large gully with active erosion the full height of the walls and along the bed. Weeping of water from the sodic subsoil may be enough to maintain flow, or at least pools within the gully, for much of the year. Photo Fleur Flanery.

Left: An example of a gully with several active head cuts moving up the slope. Photo Samantha Burt.

An unfenced gully is a hazard for sheep, vehicles and the woolgrower. Photo Fleur Flanery.

Many tablelands soils in the eastern states have high levels of the element sodium in the layer beneath about 20 centimetres, and these have no cohesive structure and dissolve and crumble easily when wet or when touched — they are called 'dispersive' and dissolve into their constituent clay, silt, and sand particles when placed in rainwater.

Erosion of the gully floor undercuts the banks which then topple in, providing more soil for the next erosion event and retaining the typical steep sides of an active gully. If the surface flow has sufficient power, the head of the gully (where the surface flow drops into the channel) will continue to erode back up the drainage network until a new equilibrium is reached between erosive power and resistance; this erosion site is called a 'head cut'. Active gullies erode upstream, often as a series of headcuts.

What is the risk of new gullies forming on my property?

The key risk factors associated with the formation of new gullies, or extension of existing ones, are:

1. large catchment areas with steep slopes,
2. erodible or dispersive soils,
3. intense rainfall or long periods of saturated soils, and
4. loss of pasture cover.

An old gully partly stabilised and filling in. Exclusion of stock will speed this repair process further. Photo Fleur Flanery.

Woolgrowers can do little to control the first three factors, although where erosion by surface flow is the key mechanism, steps can be taken to reduce the length of unhindered flow pathways or to spill converging water flows onto areas of lower risk. Gullies form along drainage paths where water is concentrated and can flow unhindered for long enough to pick up speed and have sufficient erosive power to scour soil. Using interceptor banks, contour banks, shallow grassed waterways or belts of deep-rooted perennial vegetation to slow and disperse the convergent flow, can help to reduce the effect of these risk factors.

Where seepage is an important erosion mechanism, the key is to ensure vigorous growth of pasture and/or deep-rooted native vegetation to help use the water in the soil and keep the soil profile from becoming saturated for long periods. Moving water from areas susceptible to seepage erosion using contour or interceptor banks, can also help by reducing infiltration into those areas adjacent to the gully.

The fourth factor, one that woolgrowers can manage is pasture cover. In low-lying parts of a paddock, where there is a risk of gully formation, it is essential that good vegetative cover (a minimum of 70% ground cover) be maintained, especially during seasons when intense storms are possible. This does not mean that grazing is excluded, as these are often some of the most productive parts of the farm, but the key issue is to manage grazing so that adequate cover is maintained. This will require frequent inspection of the pasture so that stock can be removed when ground cover is falling (patches of bare soil between plants become visible). Set-stocking of these vulnerable areas is often the worst policy, as sheep preferentially graze particular areas or plants so that bare areas open-up even when there is other feed not used. Instead, some form of rotational stocking is recommended, and woolgrowers often link this to other stock management activities such as parasite control.

Control of grazing by native and feral animals, especially rabbits whose burrowing exacerbates erosion, is also important in maintaining cover or to speed rehabilitation.

Removing protective vegetation by land clearing and overgrazing greatly increases the likelihood of gully formation and must be avoided.

This gully is being fenced to exclude stock and encourage natural revegetation and eventual stabilisation. The value of the potential pasture foregone is minimal, and this is a low-cost way of repairing the gully. Photo Greening Australia.

Other farming operations can increase the risk of gullies forming, for example, cultivation for re-sowing pasture and the construction of tracks across low-lying areas. These operations should be timed as far as possible to avoid periods of high rainfall when runoff is at its greatest and the erosive power of water flow is at its highest.

Should I act to manage existing gullies?

Gullies that are more than 10 to 20 years old often begin to stabilise, so only limited management action may be necessary to reduce the risk of further erosion and gully extension. As a gully extends back up toward the top of the drainage network, it carries less flow (reduced catchment area and fewer side channels entering) and the flow has less erosive power (decreased depth and shorter flow pathway) even though the slope may be steeper. Eventually a point is reached where erosion of the channel floor is reduced and the steep sides begin to batter back (reduce in steepness) due to continued erosion of their surface, but without the previous undercutting. This reduction in erosion allows vegetation to establish on the floor and (eventually) on the banks, thereby stabilising them. The gully may even start to fill in as material eroded from upslope is trapped by the vegetated floor.

When working out whether you need to do anything on your property, the first step is to inspect the gully, looking for areas of bare soil that are actively eroding, and those that have become stabilised by vegetation. If the gully appears vegetated, or at least 50% of the area has good vegetation cover, then it is probably stable or well on the way to becoming so. Look for vegetation along the floor, and battering back of the banks. In this situation, all that may be necessary to speed the process is to fence the gully to prevent access by sheep that will otherwise graze the vegetation and slow its regeneration and spread. Stock tracks also increase erosion, so removing stock

when the gully is regenerating is a good idea. It is also useful to examine aerial photographs of the gully taken over long time intervals (often these are available from state mapping agencies dating back to the 1940s). Some gullies may appear to be stable, but continue to erode and extend during extreme rain events that may occur only once each 10 to 20 years. These erosion episodes can be seen by comparing the time series photographs. Such gullies may warrant additional management, as described below.

Greater intervention is required to manage gullies that are still actively eroding so that their impact on farm productivity and water quality is reduced. It is important to determine what erosion mechanism is causing the gully to form or expand. Try to work out whether it is erosion by surface flow that is keeping the gully floor and sides active and bare, or whether it is seepage and continual dissolution of the subsoil (remember that they can occur together). If the former, then reducing or spreading the surface flows or directing them to low-risk areas is important; if the latter, then drying the soil profile with vigorous and deep-rooted vegetation and shedding water to reduce infiltration should be considered. The key steps required are:

1. fence to exclude stock;
2. consider the value of earthworks, perhaps to construct a dam on the upper reaches of the gully, and/or contour banks to redirect converging flow before it reaches the gully;
3. construct a rock shute or other form of protection where head cutting is active;
4. replant native perennial vegetation along the gully floor in areas that appear stable;
5. maintain or replant vigorous vegetation along the top of the banks and redirect surface flow away from them (this will help to keep them dry and reduce the slow subsurface weeping that dissolves the soil from beneath).

A concrete or rock drop box or chute is effective in preventing a head cut from moving further upstream, but also expensive. It is much cheaper to prevent the gully forming in the first place by good grazing management to maintain vigorous pastures or healthy native vegetation.
Photo Roger Charlton.

Preventing gully erosion is obviously much cheaper and easier than trying to cure it. Gullies can form quickly, sometimes during a single rainfall event, so maintaining a complete ground cover and minimising overgrazing, soil compaction, and physical damage to the soil surface are important preventative measures. Stopping gully erosion once it has begun is much more difficult. Technical advice about how to treat each case should be sought from local land management agencies or advisors.

This gully has become stable over time as vegetation has established along the floor and prevented the continual undercutting of the banks. Eventually the slope of the banks will reduce through further erosion and they too will become vegetated. Photo Photo Samantha Burt.

These treatments have differing costs and should be considered in relation to the likely gains. For example, fencing the gully to exclude stock may be relatively cheap (Landcare or similar funds may be available to defray capital costs), the value of any grazing lost is likely to be low, and the benefits from reduced stock losses and mustering time alone may make this worthwhile. Earthworks are expensive, but partial funding support may be available where there are wider benefits to the general community. A dam may also allow more-efficient use of the paddock and increase productivity.

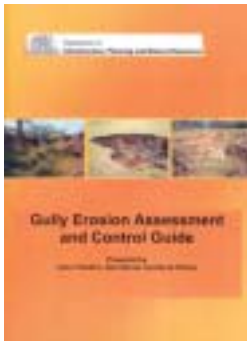
What are the costs and benefits of managing gullies?

The costs of treating gully erosion will depend on the extent and severity of the erosion, and the amount of effort required to fix it. The benefits include improvements in water quality for stock and domestic water use on-farm, improved paddock access, reduced losses of stock and valuable land, and reduced mustering time. When gully works are planned within the context of overall property and grazing management, opportunities for increased wool production may become apparent. Additional fencing and rotational grazing can be used to improve pasture composition, feed production and utilisation, as well as parasite control. A new dam near the top of a gully may provide gravity fed water allowing more-intensive use of

Photo Fleur Flanery.

highly productive pastures in the lower areas, or re-fencing of the paddock along land class boundaries for better grazing management. There are also downstream water quality benefits for neighbours and for stream ecology; these may justify support from community grants schemes.

Where can I get more information?



An excellent publication with further detailed information about planning and undertaking gully restoration is 'Gully erosion assessment and control guide', published in 2003 by the NSW Department of Infrastructure, Planning and Natural Resources. There are similar publications available in other states (see contacts list).

You'd be barking mad, if you don't start doing something about gully erosion.

Photo Fleur Flanery.

Contact list

Contact the government land management agency in your state. Other useful web sites are listed below:

Land, Water & Wool — www.landwaterwool.gov.au

Land & Water Australia — www.lwa.gov.au

Greening Australia — www.greeningaustralia.org.au

National Plan for Salinity and Water Quality — www.napswq.gov.au

NSW: Department of Natural Resources (DNR) — Tel: 02 9762 8044. Web: www.dnr.nsw.gov.au

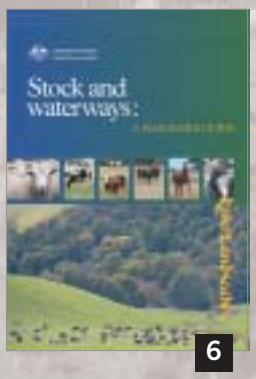
NSW: Department of Primary Industries — Tel: 02 6391 3100. Web: www.dpi.nsw.gov.au

QLD: Department of Natural Resources, Mines and Water (DNRMW) — Tel: 07 3806 3111. Web: www.nrm.qld.gov.au

QLD: Department of Primary Industries and Fisheries — Tel: 132 523. Web: www.dpi.qld.gov.au

VIC: Department of Sustainability and Environment (DSE) — Tel: 136 186. Web: www.dse.vic.gov.au

VIC: Department of Primary Industries — Tel: 136 186. Web: www.dpi.vic.gov.au



Publications for woolgrowers

The *Wool industry river management guides* bring together the latest science and recommended management practices for riparian areas within the context of a commercial wool-growing property. The Guides are available for the high rainfall regions (above 600 mm) and sheep/wheat regions (300–600 mm) of Australia. Each book has over 200 full-colour pages.

In addition www.rivers.gov.au/lww will offer an active contents list which will give you a snapshot of what is in each section.

1. High rainfall zone: product code PX050951
2. Sheep/wheat zone: product code PX050952

Managing rivers, streams and creeks: A woolgrowers guide — is a summary of the key recommendations from the 'Wool industry river management guides' and provides an introduction to river and riparian management issues on farm.

3. Product code PX051003

Are my waterways in good condition? — a checklist that provides colour coded pictures that you can use to assess the condition of your stream or creek. It is a quick and easy way to work out the health of the streams or creeks running through your property, and it suggests management actions to improve or maintain these vital parts of your farm.

4. Product code PB061114

River Insights — a publication featuring the stories of ten woolgrowers and what has motivated them to manage their rivers, creeks and streams in ways that make both economic and environmental sense.

5. Product code PK050950

Stock and waterways: a manager's guide — offers practical advice on how stock farmers can manage riparian land both productively and sustainably, and includes a number of case studies from farmers throughout Australia who have seen the benefits of changing their management practices.

6. Product code PR061132

These products are available from CanPrint Communications on freecall 1800 776 616 in hard copy, or can be downloaded from — www.landwaterwool.gov.au or www.rivers.gov.au

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