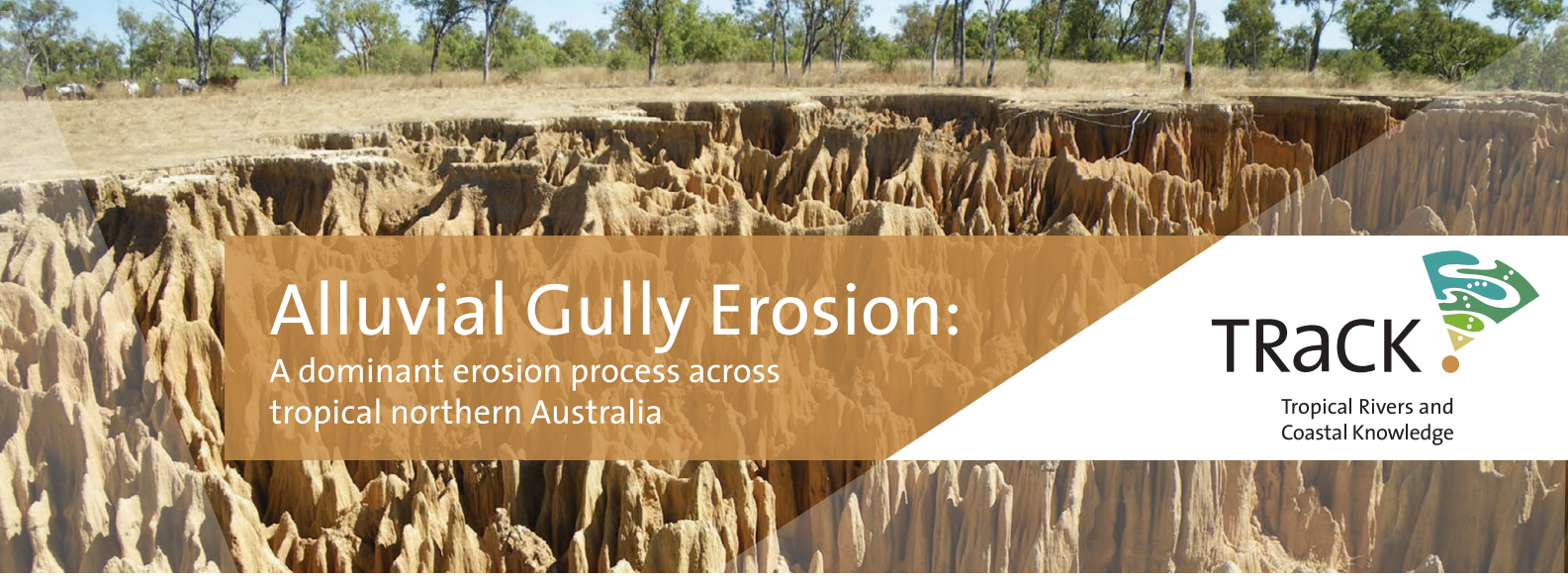


Alluvial Gully Erosion:

A dominant erosion process across tropical northern Australia

TRaCK
Tropical Rivers and Coastal Knowledge

Gully erosion into active river floodplains and terraces (relict floodplains) in northern Australia affects river health and aquatic life, industries, infrastructure, and Indigenous cultural activities. As they erode wider and deeper, gullies can make the land unusable for pastoral and agricultural use. They also carry sediment and nutrients from floodplains into rivers, creeks, lagoons, estuaries and oceans, affecting aquatic life and their habitat.

TRaCK has studied the causes and impacts of gully erosion from alluvial soils, which is widespread across northern Australia, and recommends changes to land management. Options for rehabilitating and protecting affected land are provided in this summary and an associated report.

Key findings

- Alluvial gully erosion represents a major threat to riparian and aquatic landscapes in northern Australia.
- European land use practices have accelerated the initiation and growth of alluvial gullies.
- Promoting native grass vegetation and limiting soil surface disturbance are the most important defences against alluvial gully erosion.
- Changes to cattle grazing practices can prevent alluvial gully formation and reduce erosion rates.
- In areas of strategic and cultural importance, rehabilitation tools need to be further developed to determine the best passive or direct biological, chemical, and physical methods for reducing erosion once it has begun.

What is alluvial gully erosion?

Gully erosion is the process by which running water cuts new unstable channels into soil or weathered rock, and continues to enlarge them, degrading the land.

Alluvial gully erosion occurs on active floodplains and terraces (relict floodplains) and erodes into alluvial soils originally deposited by rivers. It differs substantially from hillslope or colluvial gullying eroding into coarser material on steeper slopes in south-eastern or northern Australia.

In northern Australia, alluvial gullies typically originate at breaks in slope on steep river banks and erode floodplain soils within several kilometres of rivers.

They vary in appearance, depth, and surface area, but are commonly identified by scarps or "breakaways" at their heads adjacent to flat floodplains.

Most alluvial gullies drain directly into nearby rivers, which can deliver sediment and nutrients long distances and eventually settle in rivers, estuaries, and coastal waters. Some alluvial gullies drain away from main rivers and deposit sediment into local creeks and lagoons.

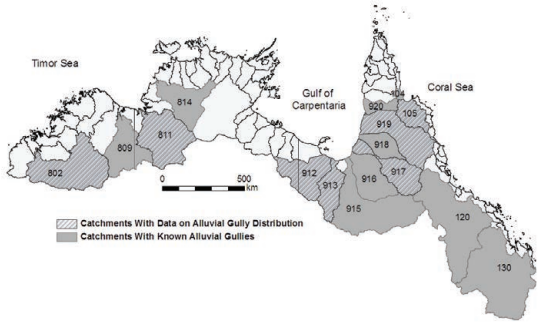
An oblique photo of an alluvial gully "breakaway" migrating away from a river corridor and consuming the floodplain savanna landscape.

Where is the erosion happening?

Alluvial gullies are common along river banks and floodplains of northern Australia, but are also found elsewhere in Australia and the world.

In Queensland, they have been mapped in the Mitchell and Normanby River catchments of Cape York Peninsula; and the Gilbert, Leichhardt, Gregory and Nicholson River catchments of the Gulf of Carpentaria. They also occur in the Victoria River catchment in the Northern Territory, the Fitzroy River catchment in Western Australia, and the Burdekin and Fitzroy rivers in Queensland draining to the Great Barrier Reef.

TRaCK researchers estimate that active gullies can cover more than one percent of the catchment area and up to ten percent of the local floodplain area.



Map of catchments in northern Australia that either have a) data on alluvial gully distribution (stipple) or b) known alluvial gullies that have not been quantified or mapped circa 2012 (dark gray).

Alluvial gully types

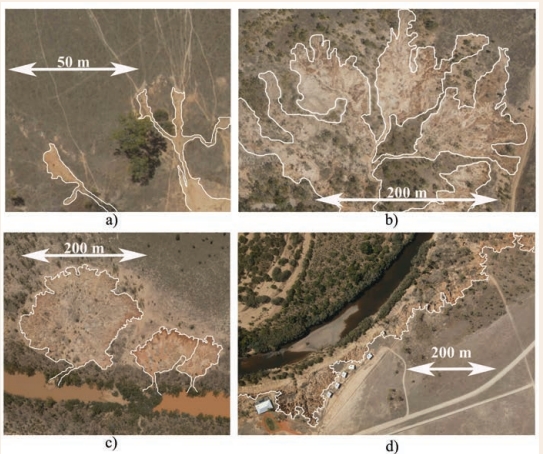
Four types of alluvial gullies have been identified by their water drainage pattern, erosion processes, and age:

- **Linear** alluvial gullies are relatively new gullies, often associated with land-use disturbances such as stock tracks, roads and fences.
- **Dendritic** gullies have branched drainage networks separated by shallow ridges, often with less distinct or non-continuous head scarps.
- **Amphitheatre** gullies have continuous head scarps, are often as wide as they are long, and drain into relatively narrow outlet channels.
- **Continuous scarp front** gullies are older and located parallel to rivers. They form when many amphitheatre gullies join together, and can be influenced by river bank erosion on bends.

Alluvial gullies can also be categorised by whether they drain into or away from the river:

- Proximal gullies drain directly into rivers.
- Distal gullies drain away from rivers and towards creeks and lagoons.

Floodplains containing both proximal and distal gullies are at risk of losing all of their original surface soil.



Examples of different planform morphologies of alluvial gullies: a) linear; b) dendritic; c) amphitheatre; d) continuous scarp front.

What causes alluvial gully erosion?

Alluvial gully erosion is caused by local topography, water runoff during rainfall and river flooding, erodible soils, and natural and man-made disturbances.

Topography

- The elevation difference between the river bed and high floodplain provide the potential energy for alluvial gully erosion. This height is influenced by river incision over geologic time. The heights of the gully head scarps are correlated to this local relief.

Water energy

- Water from direct rainfall, overland runoff, river backwater, overbank flooding, and groundwater seepage influence alluvial gully erosion. Intense rainfall onto and runoff over exposed soils often dominates erosion, but river flooding can also cause erosion. Gully initiation or acceleration may be even greater when overland flow is concentrated along animal or vehicle tracks.

Erodible soils

- Silty floodplain soils located close to river banks are highly prone to erosion due to naturally elevated levels of sodium. These "sodic" soils are easily dispersed and eroded if devegetated and exposed to heavy rainfall and concentrated water flow.

Natural disturbances

- Natural disturbances such as heavy monsoon rainfall, major river flooding, river bank erosion, drought, fire and native animal tracks influence the initiation and growth of alluvial gullies.
- Vegetation, especially perennial native grass, is the most important natural defence against the initiation and propagation of alluvial gully erosion.

Man-made disturbances

- Examples of man-made soil disturbances are cattle grazing, cattle tracks, altered fire regimes, weed invasion, fencing, building roads, clearing trees and farming. These disturbances can accelerate alluvial gully erosion by concentrating water and reducing or altering vegetation along river banks and adjacent floodplains.
- Excessive cattle grazing in riparian zones, for example, can reduce native grass cover, increase soil disturbance, and concentrate water along cattle tracks, which can initiate and propagate alluvial gullies along river banks and hollows.
- Once initiated by the combination of land use and natural factors, alluvial gully erosion is difficult and expensive to stop. Preventing gully initiation is the key to sustainable land use.

(a)

(b)

Examples of a) a cattle track cut down a steep river bank that is rapidly being transformed into an alluvial gully, and b) an alluvial gully initiated by a poorly designed road crossing a river.

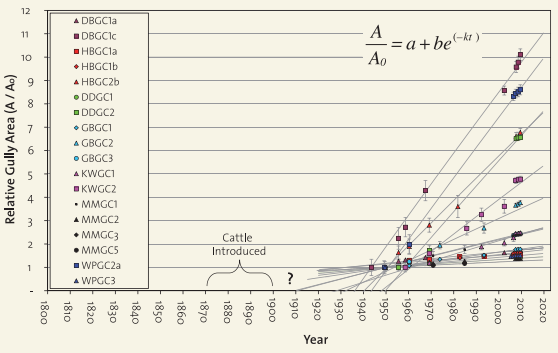
At what rates are the land and soil eroding?

The rate of recent and historic gully expansion varies widely depending on the erosion process and the location.

TRaCK surveys of 18 sites in the Mitchell catchment between 2005 and 2010 showed that gullies were enlarging by 0.3 metres per year on average, with local maximum rates up to 15 metres per year. Rates measured from historic aerial photos were slightly larger on average (0.45 m/yr). Where gullies are influenced by roads and fences, erosion rates up to 75 m/yr have been observed. Estimates of gully erosion rates in other catchments of northern Australia are generally similar to those for the Mitchell.

Historic aerial photos in the Mitchell showed that gully areas have increased between 1.25 to 10 times their initial 1949 area. Looking back in time suggests that the current phase of extensive erosion was initiated between 1880 and 1950 during the time of cattle introduction. Future gully growth projections suggest that erosion will continue for several hundred to several thousand years, growing 10 to 50 times in size and consuming on average 165 hectares per year across the lower catchment.

In northern Australia, sediment concentrations and yields from alluvial gullies are high by both Australian and world standards. For example, in the Mitchell, suspended sediment concentrations in alluvial gullies are 10 to 100 times greater than concentrations found in nearby rivers.



Relative changes in gully area (A/Ao) over time at all 18 alluvial gully sites in the Mitchell catchment fitted with a negative exponential function (with near linear results).

Sediment yields have been measured up to 350 tonnes per hectare per year. Across the Mitchell catchment, ~ 4 million tonnes of soil erode annually from alluvial gullies.

What are the impacts and implications?

Alluvial gully erosion consumes riparian vegetation, damages infrastructure (e.g. roads, dams, yards, and buildings), and degrades cultural sites and uses.

Gully erosion into productive "frontage" country along rivers reduces the land available for pastoral, agricultural, or environmental benefits.

Excess sediment can harm aquatic life, for example through fish gill damage, reduced feeding opportunities and production, and smothering or infilling river habitat.

Sediment from alluvial gullies can accumulate in off-channel floodplain lagoons and in-river pools, reducing the habitat volume and productivity of these environments for aquatic life and humans.

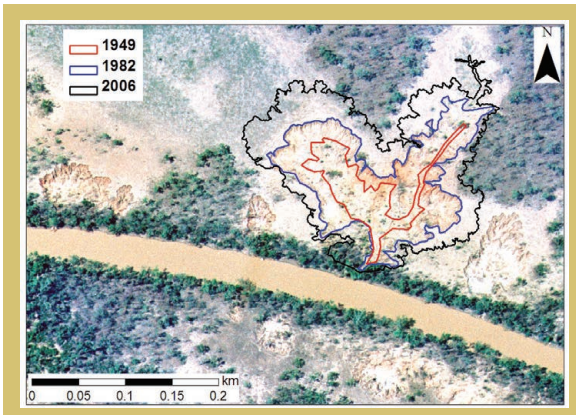
Further downstream, fine gully sediment and nutrients originating from gullies can wash into estuary, coastal, and reef habitats, affecting marine life and navigation routes.

Preventing gully initiation

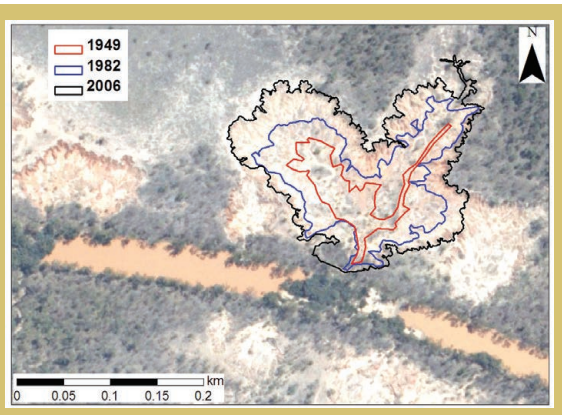
To prevent new gullies from forming, and to slow the erosion of existing gullies, graziers need to:

- Control the movement of cattle across steep banks of rivers and lagoons.
- Prevent overgrazing of 'river frontage' on floodplains and terraces.
- Avoid building and grading roads and fences down steep stream banks.

In the most erosion-prone floodplain areas, the complete exclusion of cattle should be considered on a large scale.



a) 1982 Photo



b) 2006 Photo

Changes in gully scarp location from a) 1982 to b) 2006 at a Mitchell floodplain lagoon with 1949 area for reference. Note how the floodplain lagoon has filled in with sediment from the expanding alluvial gullies.

Rehabilitating eroded land

Fencing off to allow natural regrowth

Allowing grass and trees to naturally regrow and expand is likely to be the most practical and cost-effective way to reduce alluvial gully erosion on a large scale. Natural vegetation can be resilient once disturbances, such as cattle, are removed. Increasing grass vegetation and reducing cattle track density in the small floodplain catchments above gullies can reduce water runoff and potentially slow down the growth of gullies.

Recovering vegetation within gullies can be difficult due to the nutrient poor, sodic sub-soils. However, eucalyptus and acacia trees, native and exotic grasses, and weeds have been observed to progressively recolonise alluvial gully floors once eroded, increase vegetative roughness, and promote sediment storage.

When fencing a riparian zone off from cattle to reduce soil disturbance, caution is needed when locating the fence (preferably on the flat high floodplain well away from banks) and in constructing and maintaining the fence to minimize rill and gully erosion.

Planting specific grass and tree species

Along with cattle exclusion, planting specific species within eroded gullies and surrounding floodplains and terraces could proactively accelerate recovery. Plants tolerant to nutrient poor, sodic soils, such as deep-rooted perennial grasses, should be utilised where practical.

Planting locally appropriate species over large areas has been an effective management approach in stabilising gully areas around the world (i.e. India, China, Africa, New Zealand, USA, and to a lesser extent, Australia).

Direct intervention

Due to the large expense per unit area, direct intervention to slow alluvial gully erosion using physical structure, chemical and biological tools is recommended only for the more strategic or important cases. This may cover areas where there are buildings, yards, roads, dams, key waterholes, biodiversity hotspots, and/or cultural sites. Where possible, direct intervention should target the causes of erosion (i.e. excess water concentration) rather than just the symptom (i.e. the gully itself).

Berms above gully heads can be used to frequently divert excess water to safe disposal locations. Existing gullies can be treated with drop and grade control structures, filling and slope battering, gypsum addition to sodic soils, organic material addition, and revegetation with native and exotic grass species, often in combination for best results.

Detailed trials and monitoring of different techniques should be conducted to identify the most effective and practical methods for erosion control. This is partially underway in the Normanby catchment where trials are being conducted using both direct and passive approaches.

Find out more

Contact Dr Jeff Shellberg or Dr Andrew Brooks,
Australian Rivers Institute, Griffith University

Email: j.shellberg@griffith.edu.au,
Phone: +61 (0)401 926 288;
Email: andrew.brooks@griffith.edu.au;
Phone: +61 (0)427 232 709

Download the full report:
'Alluvial gully erosion: A dominant erosion process across tropical northern Australia'
www.track.org.au/publications/registry/track1843

To find out more about TRaCK

visit **www.track.org.au**
email **track@cdu.edu.au**
phone **08 8946 7444**

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