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Contour Furrowing: Local Landscape Processes Determine Results

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Abstract

Contour furrows act to impound rainfall runoff and create favourable situations for plant growth. In the Western Catchment (NSW), furrowing and other mechanical treatments have been used since the mid-20thC. In 2009 prior furrowing works were reviewed, using published studies, residents' observations, and geomorphic investigation of field sites. Geomorphic processes were a focus because they are fundamental to ecological permanence and (unlike vegetation surveys) independent of recent local weather. Treatments deemed successful were >10 years old, showed self-sustaining geomorphic processes and increased vegetation. Each site's natural geomorphic processes were important contributors to the furrowing outcome. Furrowing was found to be ineffective on alluvial plains. Stony gilgai sites were effective when the treatment design worked within the existing gilgai structures (especially furrow spacing and placement). Ironstone ridge sites were effective where soil permeability was re-established, with organic content a likely factor. Critical factors for success were site selection (avoiding gullied, water-starved, high-use, steep, or base-of-slope locations), treatment design (using local landscapes to determine furrow spacing and length, not furrowing stony bands in gilgai land systems), treatment installation (accurate contour placement of furrows), and post-treatment management (total grazing management is critical).

Introduction

To ensure the best results from future rangeland rehabilitation, furrowing works were examined in a study commissioned by the NSW Western Catchment Management Authority (WCMA) and undertaken in 2009 by the primary author and WCMA staff. The aim was to establish whether previous contour furrowing treatments in western/central Western Catchment were successful, and to identify factors contributing to the outcome.

Information was collected from desktop studies and from landholders, rangeland managers and ex-Soil Conservation employees. From this, typical sites were selected for field investigation, where the characteristic geomorphological processes were noted, the degree of treatment success assessed and the relationships between treatment, outcome and geomorphology analysed.

In this study a treatment was defined as successful if landscape function (*sensu* Tongway and Hindley 2004) was re-established. The criteria for self-sustaining landscape function were visible evidence of appropriate geomorphic activity, increased vegetation (c.f. nearby untreated or degraded land), and treatment age ≥ 10 years.

Geomorphology (the geology of landscape) is the combined result of all the processes at work in an area: its soils, geology, slope, landforms, hydrology, bio-physical interactions and climate. Geomorphological processes are important to the rangelands, because where water and nutrients are limited, processes which control their distribution ultimately govern ecology. Geomorphic processes were chosen as a tool for assessing treatment outcomes because 1) long-term success is only achieved if the runoff-runon initiated by furrowing remains after the furrows have faded, which requires the re-establishment of active geomorphic processes, and 2) signs of geomorphic processes are robust and relatively independent of weather's seasonal and spatial variability.

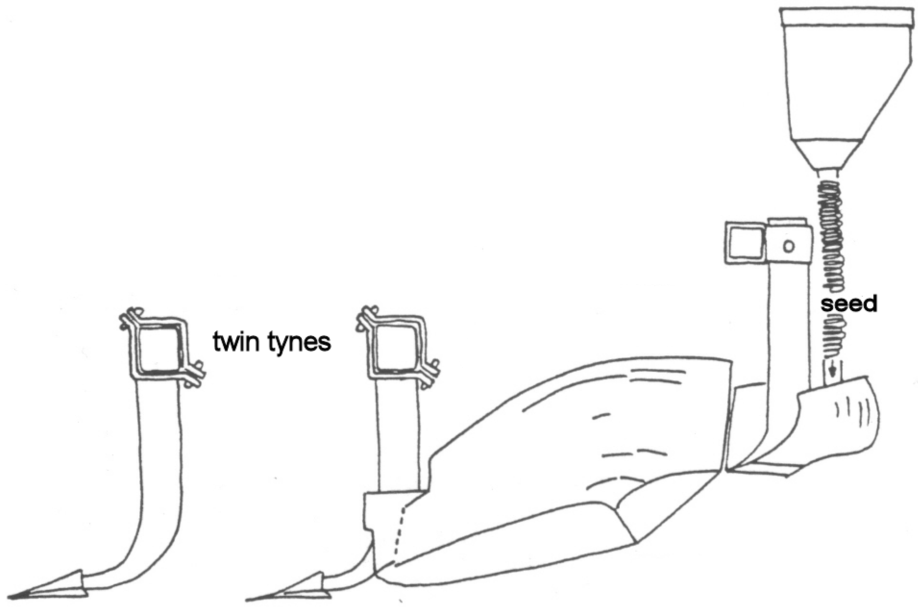

Fig. 1 This furrower was designed by the NSW Soil Conservation Service. It breaks the ground, clears the furrow of loose soil, creates windrows, prepares a seedbed, drops seed, and covers the seed with loose soil. From Tatnell, 1989.

Contour Furrowing

The equipment and techniques of furrowing evolved from various early treatments, through programs at Cobar Experimental, to the works around Broken Hill in the 1980s-90s, culminating in the specialist furrower designed by the Soil Conservation Service of New South Wales and now held by WCMA (Fig. 1). (Cunningham 1974, Cunningham *et al.* 1976, Green 1989, Tatnell 1989, Tatnell and Beale 1990). Furrows were placed on gentle hillslopes, using surveying to ensure each furrow was on the contour. The furrow spacing was originally designed to be similar to the space between natural vegetation bands of stony gilgai (Fig. 2) (Green 1989, Tatnell and Beale 1989). If the furrowing works well, the seeded plants will grow along the furrow line. Local plants will also establish, provided there is a seed source nearby. The vegetated patches may get bigger as plants set seed and new generations establish, extending along the furrow, or perhaps extending upslope in places where moisture accumulates. There will always be bare areas and they are an important part of the functioning landscape, shedding rain for the vegetated patches downslope.

In furrowing, the surface is broken and the underlying soil fractured to some depth. Soil is moved out of the broken area, creating a furrow and bank. The WCMA furrower also creates a seedbed and deposits seed. The furrow/bank line intercepts runoff from the bare area immediately uphill, promoting infiltration and plant growth. This restores landscape function by creating a runoff-runon system (mimicking natural banded vegetation systems), which can be very efficient in trapping rainfall. However, in some sites the furrow/bank line subsides with time but the vegetation remains, yet in other places the line remains but vegetation is poor or absent. What allows a treated area to be both successful and self-sustaining?

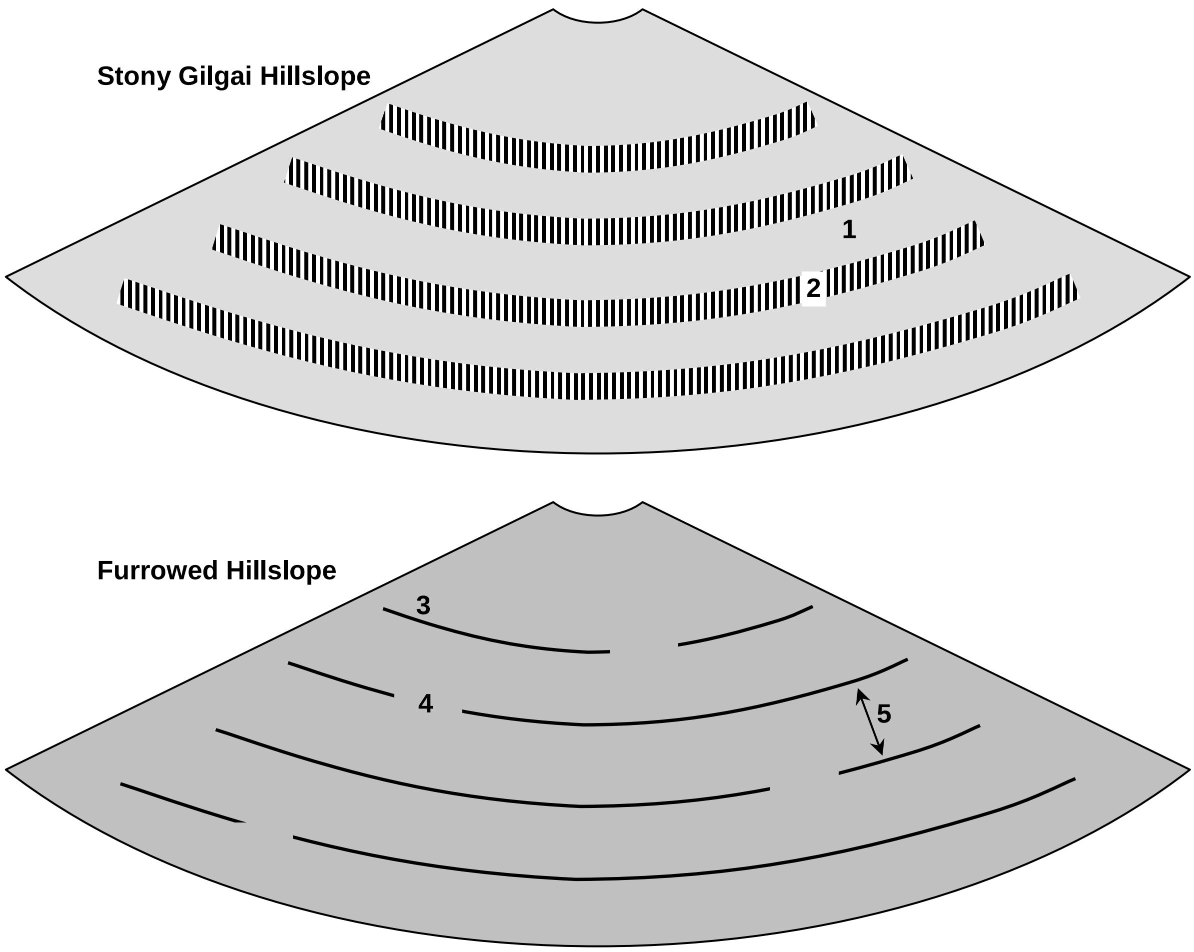

Fig. 2 Top: sketch of a natural stony gilgai hillslope, with bare stony areas (1) shedding rainwater onto the lines of vegetation (2, vertical stripes). The vegetated bands are contour-parallel and are efficient at trapping runoff. Bottom: sketch of contour furrowing on a hillside. 3, the furrows (dark lines) are contour-parallel. 4, there are occasional gaps in the furrows, to allow excess water to drain. Gaps are offset, to minimise risk of gullying. 5, the distance between the furrows (furrow spacing) is similar to the interval between vegetated bands in nearby stony gilgais.

Results

Field sites showed that the degree of treatment success was linked to how closely the geomorphic processes created by the treatment fitted in with the local natural processes. While the intent of contour furrowing is to re-establish landscape function by the creation of runoff-runon patches, the key to furrowing success is not the patches alone. Success depends on re-establishing the local geomorphic processes, which will then allow the patch dynamics to function again. Therefore, in different types of country, different aspects of the rehabilitation treatment were more significant.

Furrowing was seen to have not worked at all on alluvial plains. The slope-driven processes of furrows don't work on flat floodplain, and the furrows are destroyed by inundation.

Furrowing had moderate degrees of success in stony gilgai country if the furrows were placed in non-stony patches, were accurately placed along the contour, and furrow spacing was similar to the interval between vegetated bands nearby. (The width of local natural stony bands indicates how much runoff area is needed to support a vegetated patch, since stone bands are the source of runoff that allows the vegetated bands to flourish; Wakelin-King 1999.) Furrowing had poor results where spacing was too close, where furrows were placed in stony patches, or where gullying was established. The key geomorphic process allowing the treatment to be self-sustaining is the development of gilgai function, visible as macropores ("crabholes").

Furrowing (and other treatments) had moderate to good results in ironstone ridge country. In some sites better growth occurred where there was a higher runoff:runon ratio, consistent with the larger natural patch scale. Accuracy in placement along contour was less critical, indicating that runoff interception was not the prime geomorphic process. Plant material in successful furrows coincided with an absence of soil hard-setting, and consequent good permeability. Experimental plots at Lake Mere, where runon patches were established without breaking the soil surface, were successful initially (Tongway and Ludwig 1996) but had relapsed by the time of this study, suggesting mechanical creation of permeability is necessary. The key geomorphic process here appears to be soil permeability, first created mechanically during treatment, then maintained by vegetation (possibly by its contribution of organic material to the soil).

Recommendations arising from this study include:

- Suitable sites slope gently, receive some (not too much) runoff, are not gullied, are not too close to high-use areas and do not have untreated Invasive Native Scrub.
- Reduce erosion risk by working from top of slope downwards, by having contours accurately surveyed and by having occasional gaps that are offset up and down-slope. Convergent slopes and high-runoff areas require closer spacing.
- Maximise results by accurate furrow surveying and placement in favourable locations, at intervals similar to nearby natural examples.
- Post-treatment grazing management is critical.

Conclusions

This study documents some long-term successes from contour furrowing and tyne pitting in the Western Catchment. It demonstrates that the reasons for these successes are variable: in different types of country, different geomorphic processes operate and so the treatments are beneficial in different ways. Even for a single rehabilitation technique, the different types of country require different treatment designs. It is certain that a one size fits all approach is unsuitable for such a large area. The general principle that arises from this study is that a rehabilitation technique should be used according to its fit with the natural landscape processes of the area.

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