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The geomorphic signature of bare-nosed wombats (*Vombatus ursinus*) and cattle (*Bos taurus*) in an agricultural riparian ecosystem

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ABSTRACT

Riparian agricultural environments in eastern Australia are widely used for cattle grazing, but are also preferred habitat for native, soil-disturbing mammals such as the bare-nosed wombat (*Vombatus ursinus*). We examined the effects of mound construction by wombats, and track development by cattle and wombats, on soil displacement in a riparian landscape at high and low levels of cattle usage. Splash erosion was measured on mounds and inter-mounds with splashboards, and changes in the profiles of cattle-wombat tracks were assessed using a profilemeter. Twice as much soil was detached by splash erosion from mounds than inter-mounds, irrespective of cattle usage, and about three-times more coarse sand and 40% more fine sand was detached from mounds and inter-mounds at the high cattle sites. Increasing amount of rainfall corresponded with increasing splash erosion, but only on the mounds. The volume of soil displaced from wombat and cattle tracks ranged from 7.9 to 88.8 $m^3\ ha^{-1}$ (4.7 to 118.7 $t\ ha^{-1}$), but there were no differences in relation to cattle usage. Our results indicate that track development by cattle and wombats and mound construction by wombats may be substantial geomorphic processes given the large mass of soil displaced. Our results suggest that mounding by wombats may be an important process in riparian environments by providing a range of microsites that favour different plant cover densities.

1. Introduction

Soil movement and sedimentation are important processes in the development of floodplains and riparian systems (Naiman et al., 2010). Much has been written about the abiotic effects of natural riparian processes on riparian systems, particularly the roles of stream flow and river bank erosion (e.g. Hooke, 1979; Poff et al., 1997). Similarly the effects of exotic herbivores on riparian systems are well known. For example, livestock grazing and trampling influence riparian plant species through either direct removal of biomass through herbivory or by the destruction of photosynthetic and reproductive tissues through trampling (Kauffman and Krueger, 1984; Belsky et al., 1999). Less well studied, however, is the role that native herbivores play in riparian systems, with the notable exception being that of the North American beaver (*Castor canadensis*; Naiman et al., 1988; Wright et al., 2002). Because of the wide range of activities associated with browsing, burrowing and trampling, animals can have dramatic, and often contradictory, effects on ecosystem functions (Naiman, 1988; Naiman and Rodgers, 1997). Despite the paucity of information on the effects of native animals in riparian systems, an emerging body of evidence suggests that they may play important roles by dislodging and moving sediment (Moore, 2006; Byers et al., 2006; Bartel et al., 2010). These processes could be as important, or more important, in modifying riparian landscapes than abiotic processes (Butler, 1995).

An example of a native herbivore that occurs in riparian environments is the bare-nosed wombat (*Vombatus ursinus*). Wombats are widely distributed mammalian herbivores that occur within riparian, temperate forest landscapes in south-eastern Australia (McIlroy, thesis). They typically prefer stream bank habitats that provide a readily available source of burrow sites (McIlroy, thesis; Skerratt et al., 2004; Borchard et al., 2008). Wombats create large mounds of ejected soil when constructing their underground tunnels, particularly in the banks of higher order streams (Borchard et al., 2008). In riparian systems, wombats prefer to burrow under short stature vegetation, though burrowing can occur on stream bank areas devoid of any canopy cover (Borchard et al., 2008).

The effects of wombats are not limited to mounds and burrows. They create tracks (i.e. pathways that link their burrows with areas in which they graze), or reinforce existing tracks created by cattle in heavily used riparian habitats. Wombats can therefore have potentially significant effects on terrestrial ecosystems by displacing large volumes of soil and making it available for movement by processes of wind and water erosion. Estimates of soil movement for the closely-related southern hairy-nosed wombat (*Lasiorhinus latifrons*) are up to 88 $t\ ha^{-1}$ (Steele and Temple-Smith, 1998). Soil trampled along tracks

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and pathways used by wombats and cattle may also be subject to the formation of rills and gullies. The potential geomorphic influence of wombats on the riparian landscape, however, is dependent on the *per capita* production of burrows, mounds and tracks, which is highly related to the size of the resident population. Given their effects on soils in riparian systems, wombats can be considered to be important biogenic agents in pedogenesis (Heimsath et al., 2000).

The distribution of bare-nosed wombats has contracted considerably since the early 20th century when large areas of forested land in south-eastern Australia were cleared for agricultural use (Triggs, 2009). In these agricultural landscapes wombats are currently restricted to patches of riparian vegetation, though their population densities can be as high as 1.9 animals ha^{-1} (Skerratt et al., 2004). The same riparian environments are also highly favoured by domestic livestock, particularly dairy cattle, for forage, water and shelter (Borchard and Wright, 2010a). This situation typically brings wombats into direct conflict with landowners because of the assumption that they destroy fences and foul water supplies, and that their extensive burrows pose a threat to livestock by increasing the chances that cattle will sustain injury by stumbling over the burrows (Borchard and Collins, 2001; Borchard and Wright, 2010b; Borchard et al., 2010). Whilst the deleterious effects of cattle grazing, trampling and wallowing are increasingly well understood (Trimble, 1994; Trimble and Mendel, 1995; Jansen and Robertson, 2001), little is known about the geomorphic consequence of wombat activities such as digging and trampling. No research has been conducted that quantifies the amount of sediment transported into streams by the degradational and excavational activities of wombats either individually, or in combination with cattle.

In this paper we present field observations and empirical measurements of the effects of wombats, with and without cattle, on soil movement in a riparian environment in eastern Australia. Our focus is on a peri-rural, agricultural environment where cattle grazing has been a predominant land use for more than 150 years, but where the surrounding relict vegetation still provides suitable habitat for wombats. In this area, wombats and cattle frequently come into close contact, and both contribute to soil displacement through burrow excavation and soil deposition (wombats) and the trampling and dislodgement of soil along tracks (wombats and cattle).

2. The study area

The study was conducted along sections of the Kangaroo River, Barrengarry Creek and Brogers Creek in Kangaroo Valley about 150 km south of Sydney, New South Wales (NSW), Australia (34°43′S, 150°31′E; Figs. 1 and 2). Kangaroo Valley was cleared extensively for dairy farming in the mid- to late-1800s (Griffith, 1986) and is characterised by undulating floodplains and terraces with minor depressions and drainage lines (Hazelton, 1992). Deep alluvial soils occur on the floodplains, and gleyed podzolic soils and soloths occur on the lower terraces and depressions (Hazelton, 1992). Average annual rainfall, measured 24 km south of the study area (Nowra), is 1110 mm. The average minimum and maximum daily temperatures are 16.3 °C and 25.8 °C in February and 6.2 °C and 15.8 °C in July, respectively (Bureau of Meteorology, 2006).

The study area was chosen because it supports a high density of wombats (Giles and Lonnon, 1999) and has a long history of grazing by dairy cattle (Griffith, 1986). Sixteen sites were chosen, each comprising a 100 m section of stream bank. The study sites included the area from the edge of the stream to the top of the bank where the slope levelled out. Distances from the water's edge to the top of the bank ranged from 7 m for steeper banks to 17 m for more gently sloping banks. The streams ranged from deeply-incised and relatively straight with steep banks up to 31°, to meandering and sinuous, with more gently sloping banks of 12°.

All of our measurements were collected from three microsites (wombat mounds, cattle-wombat tracks, non-track/non-mound control sites) at each of the 16 stream bank study sites. The study sites were categorised as having either 'low' or 'high' wombat use, based on the abundance of burrows (entry holes surrounded by mounds). Low use sites had ≤6 burrows per 100 m length of stream, whilst high use sites had ≥9 burrows per 100 m. However, not all burrows had mounds associated with them, possibly due to trampling by cattle or rain splash erosion caused by high rainfall events. Eight

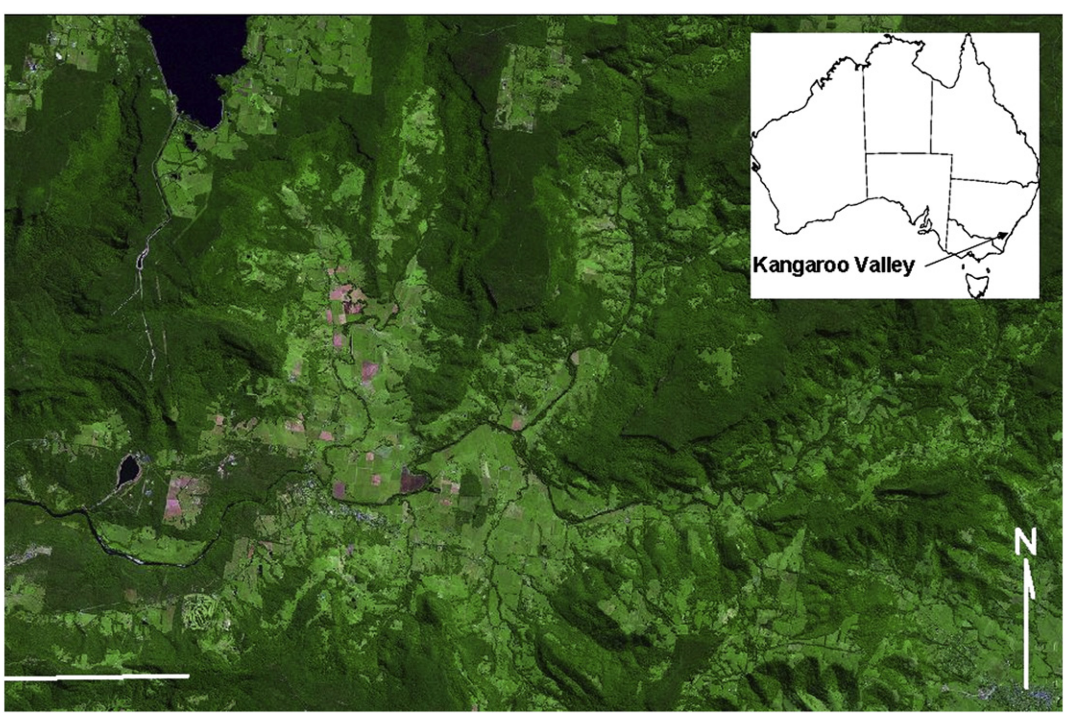

Fig. 1. An aerial photograph of the study area within Kangaroo Valley, New South Wales, Australia. The bar is equivalent to 5 km. Source: Mapinfo Co, 2007.