The Evil of Sluits: A Re-assessment of Soil Erosion in the Karoo of South Africa as Portrayed in Century-Old Sources

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Abstract
Deep, linear gullies are a common feature of the present landscape of the Karoo of South Africa, where they were known locally in the early twentieth century as 'sluits'. Recent research has shown that many of these features are now stable and are no longer significant sediment sources, although they are efficient connectors in the landscape. Because most of the gully networks predate the first aerial photographs, little is known in the scientific literature about the timing of their formation. One secondary source, however, throws interesting light on the origin of these features, and the early response by landowners to their rehabilitation. The Agricultural Journal of the Cape of Good Hope at the turn of the Twentieth Century carried a number of articles by farmers and agricultural officers concerning the "evil of sluits". The authors gave accounts of widespread incision of valley bottoms by deep, wide gullies. Many of these gullies had been in existence for some thirty years but apparently had formed within living memory. A number of attempts to prevent further erosion had been put in place at the time of writing. This paper presents a review of land degradation, specifically gully erosion, and rehabilitation recommendations as given by authors writing in this journal. It reflects on the findings in the context of assessing land degradation processes through the local knowledge portrayed in the journal.

Key words: gully erosion, Karoo, European settlement, local knowledge, environmental history

1. Introduction

The Karoo of South Africa is a semi-arid to arid region that covers an area of approximately 427 025 km^2 in the Cape Province of South Africa (Figure 1). Despite a low mean annual rainfall varying from around 100 mm in the west to over 400 mm in the east, this area has supported a livestock industry for many hundreds of years, firstly by indigenous pastoralists and later, from the 1700s, by European settlers. Several authors have described land degradation in the form of soil erosion coincident with a loss of vegetation cover and species change, as presented in section 2. They ascribe degradation to the intensification of human settlement in the second half of the nineteenth century, but the timing of the start of soil erosion remains vague. Information garnered from travelers' journals and government reports fails to give a convincing picture of the soil erosion process since the start of European settlement.

This paper explores an as yet little tapped source of local knowledge on erosion in the Karoo at the turn of the nineteenth century - the Agricultural Journal of the Cape of Good Hope (hereafter referred to by its acronym AJCGH), published between 1889 and 1910. This was the official mouthpiece of the Department of Agriculture of the Cape Colony; it educated farmers on best agricultural practice through publishing reports on agricultural experiments and providing a forum for debate (Bennett, 2011). In 1899 the official circulation figure was 5,000 (Brown, 2003a).

A number of authors have used this journal recently as a source of information on agricultural problems and developments at the turn of the nineteenth century. A literature search via Google Scholar using the search terms 'Agricultural Journal of the Cape of Good Hope' or its acronym AJCGH produced the results given in Table 1. There has been a clear bias towards papers investigating livestock disease, followed by pest plants, especially prickly pair (*Opuntia*). Two environmental historians who have made extensive use of the journal are van Sittert (1998, 2000, 2002, 2004) and Brown (2003a, 2003b). It is surprising, however, that hitherto only two articles that addressed the soil erosion issue (Bradfield, 1908, Kanthak, 1908) appear to have been cited in the standard academic journal articles and only Bradfield (1908) within the context of erosion (Beinart, 1984).

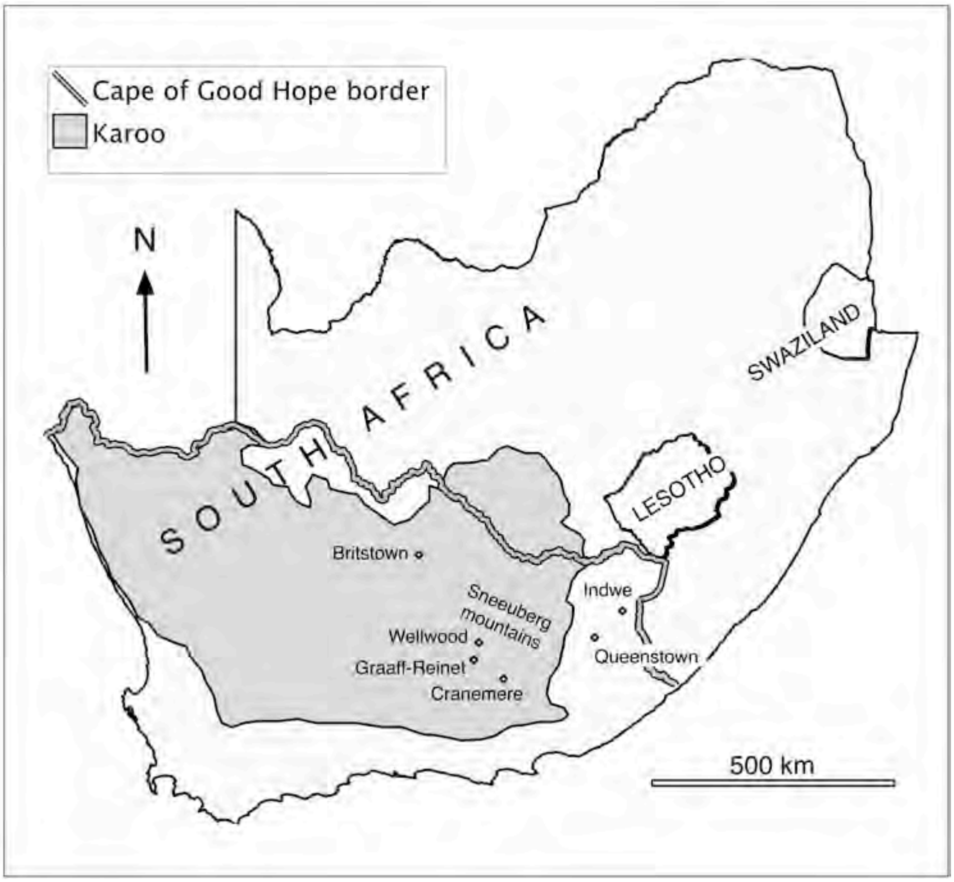

Fig. 1 Location of the Karoo in South Africa. The border of the Cape of Good Hope was reconstructed from Blackie's map of 1860. Place names refer to places mentioned in the text.

Table 1. Citation of papers published in the Agricultural Journal of the Cape of Good Hope (AJCGH) based on a Google Scholar search.

Topic	No. of AJCGH papers	No. of citations
Livestock disease	14	66
Prickly pear and other pest plants	5	21
Erosion and degradation of vegetation cover	2	12
General agriculture	2	5
Forestry	1	2

Table 2. List in date order of the key articles from the AJCGH that address the debate over land degradation.

Author	Date	Title
Smith	1989	Deterioration of old sheep-farming districts
McNaughton	1898	Silt in dams (correspondence)
Ogilvie farmer	1891	Fifty years of sheep farming in South Africa
Hobson	1900	Deterioration of veld in the Midlands (266-270)
Anon	1900	Deterioration of grazing lands (530-535)
Bradfield	1903	The preservation of the soil from damage caused by sluits
Bradfield	1903	Sluits and their remedy some practical notes (correspondence)
Sim (District Forest Officer)	1904	The evil of sluits - and how far it could be prevented and remedied by tree-planting.
Gordon (Director of Irrigation)	1904	Sluits- their evil and prevention
Dugmore	1905	Sluits - their evil and prevention
Anon	1905	The utilization of Karoo flood water: Mr. Southey's success at Schoombie.
Braine	1906	Dongas or sluits - their effect and treatment
Bradfield (farmer and miner, Indwe)	1908	Erosion and desiccation of the Karoo
Kanthak	1908	The destruction of mountain vegetation: its effects upon the agricultural conditions in the valleys

A number of articles in this journal document government officials' and farmers' perceptions of and responses to land degradation in the Karoo and other areas of the Cape of Good Hope (Figure 1), with the main debate ongoing from 1900 to 1908 (Table 2). It is the unexplored debate over soil erosion and "The Evil of Sluits" that is presented in this paper. As explained in Section 2, an unanswered question in the current erosion debate is the timing of valley floor gully erosion. A key question addressed in this paper is therefore 'when did valley floor gully erosion begin and why?'.

Section 2 reviews the current debate about degradation in the Karoo and highlights the lack of evidence cited for the timing of valley floor incision. Section 3 presents the debate on soil erosion and, specifically, "sluit" erosion that was actively promoted through the AJCGH at the turn of the century. Supporting evidence for the timing of soil erosion is provided by an analysis of contemporary rainfall data in section 4. The discussion in section 5 summarizes the key findings and presents an appraisal of the AJCGH articles as a form of local knowledge.

2. Land degradation in the Karoo - the research context

Land degradation in the Karoo has been the subject of academic debate since Acocks (1953) published his expanding Karoo hypothesis. His assertion was that poor veld management was causing the encroachment of grassland by drought resistant shrubs and that, if unchecked, would advance to transform the grasslands to the more humid east. Since then a number of authors have challenged this view, suggesting that observed changes may, in part, be a dynamic response to a variable climate subject to wet and dry periods (Meadows and Sugden, 1988, Hoffman and Cowling, 1990; Bond et al., 1994; Dean et al., 1995; Hoffman et al., 1995).

Vegetation changes are mirrored by changes to the soil, with soil erosion being a prevalent feature of the Karoo landscape (Roux and Vorster, 1983; Rowntree, 1988; Boardman et al., 2003; Foster et al., 2012). Two types of erosion dominate visually. The first is gully erosion, taking the form of either incised channels along valley floors or hillslope gullies, which may be discontinuous (Rowntree, 1988; Grenfell et al., 2012). These incised channels can take dramatic dimensions and are locally known as dongas or sluits. The second form of erosion is badland erosion that takes the form of dense dendritic networks of narrow gullies, located mainly on colluvial footslopes (Boardman et al., 2003). Badland erosion is often associated with widespread loss of topsoil, exposing subsoil that is bare of vegetation.

Because ecologists carried out much of the early research on Karoo degradation, the focus of the research was vegetation (cf Acocks, 1953; Dean et al., 1995). Roux and Vorster (1983) and Rowntree (1988) drew attention to the relationship between soil erosion and vegetation cover. More recently Boardman et al., (2003) and Keay-Bright and Boardman (2006, 2007, 2009) turned their attention to a detailed investigation of soil erosion. They concluded that the spatial extent of both gully networks and badland areas was established by the time that the earliest aerial photographs became available, 1945. In line with the ecologists, they linked the initiation of erosion to permanent European settlement from the early nineteenth century, with its associated stock farming and communication networks in the form of wagon tracks (Neville et al., 1994). They pointed to droughts in the 1920s and high stock number peaking in the 1930 being contributory factors, but could not provide substantive evidence of when erosion began. Their work was taken further by Foster et al. (2005), Foster et al. (2007), Foster et al. (2012), Rowntree and Foster (2012) who reconstructed historical catchment sediment yield using palaeo studies of sediment in farm dams in the Sneeuberg Mountains. Their research revealed two key findings. First, sediment yields from the four catchments were relatively low prior to 1940s, but increased thereafter. One dam dates back to 1843 (Cranemere) and another to 1909. Both showed low sediment accumulation rates up to 1960, with dramatic increases in the 1970s. Second, although dramatic features, valley floor gullies are no longer a significant source of sediment deposited in farm dams. The presence of ^{137}Cs in significant quantities in the upper layers of the sediment indicates that, at least during the second half of the twentieth century, surface soils rather than gullies side walls contributed the bulk of the sediment. This confirmed the findings of Keay-Bright and Boardman (2006) that gullies had stabilized by the 1940s. By this time, therefore, gullies formed conduits for sediment transport from hillslopes (especially badland areas (Rowntree and Foster, 2012)) rather than acting as sediment sources.

The recent research on erosion in the Sneeuberg Mountains of the Karoo has thus demonstrated that hillslope erosion is still active and sediment transport to farm dams has indeed increased over the last sixty to seventy years, but that the network of valley floor gullies has been established for considerably longer. The recent Karoo academic literature sheds little light on when these gullies formed. Boardman et al. (2003 p. 173) state “It is not possible to provide a precise date for the commencement of gully erosion within the study area [the Sneeuberg].” They quoted the conclusions of Neville et al. (1994) and Neville (1996) who analyzed the accounts of travellers who had passed through the Seekoe Valley to the north of Compassberg prior to 1892. No evidence was cited that indicated that the channel of the Seekoe Valley was incised at the time, but that on the northern plains the river consisted rather of a series of disconnected pools (Barrow, 1806). Neville et al. (1994) describe the development of north-south ox-wagon routes from Graaff-Reinet to the northern Karoo plains, which followed connecting river valleys up and over the escarpment of the Sneeuberg Mountains and were well established by the 1840s. He ascribed the distribution of modern erosion to these trackways, in most part to the large numbers of livestock that were lead along these routes, grazing the vegetation and trampling the earth. Barrow (1806) describes meeting a butcher on his way from the Sneeuberg to Cape Town with a herd of some 500 cattle and 5000 sheep.

Authors writing about the Karoo have often referred to travelers' journals in an effort to reconstruct the environment during the time of early European settlement (cf Neville et al., 1994). Barrow (1806) describes his journey across the landscape between Cape Town and Graaff-Reinet and northward over the Sneeuberg Mountains. The Karoo is invariably described as desert; the only mention of grass cover is for the Sneeuberg where the vegetation consisted of tufts of long grass, with small healthy shrubs. There is thus no indication from Barrow's writing that the Karoo was of a more grassy nature at the beginning of the nineteenth century. Preston-Whyte and Tyson (1988) document droughts recorded during the nineteenth century. Their first record was for 1825-1829, so there is no evidence to suggest that Barrow was travelling during a drought period. Dean et al. (1995) mention devastating seasonal droughts between 1813 and 1836, again well after Barrow's journey.

Barrow (1806) describes a number of rivers that he crossed. Most of these were wide and evidently of a braided character with banks lined with "mimosa" (*Acacia karoo*). There was little water flowing at the time of his journey, but he describes in one instance evidence of higher torrent-like flows in the form of woody debris deposited on shelving channel banks. Only one river channel is described as deep and narrow, which could have described an incised channel, but nowhere does he mention channel erosion as being a problem. It is unlikely that the presence of deep gullies would go without comment on a journey by oxwagon. Compassberg, the highest mountain in this region, was described by Barrow as being surrounded by meadows from which springs of water flowed. Meandering river courses were flanked by reeds. These streams are now incised several metres into the former meadows (Meadows and Sugden, 1988).

Evidence therefore points to channel incision and gully erosion being established sometime between 1806 and 1945, congruent with other areas globally where recently established European farming systems had created a landscape disturbance (Patton and Schumm (1975), Cooke and Reeves (1976) and Turner et al. (2003) for the USA; Brooks and Brierley (1977), Brierley and Murn (1977), Brierley and Friers (1999) for Australia). When in this period is still open to debate. The following section presents the views of authors writing in the AJCGH that provide indications of when severe gullying began, possible causes and recommended remedies.

3. The Evil of Sluits

3.1 Deterioration of grazing lands - the overstocking hypothesis

Overstocking is often cited as a cause of land degradation in the Karoo (cf. Dean and Macdonald, 1994). An early article on the deterioration of grazing lands in the Cape Colony appeared in 1889 (Smith, 1889) in response to concerns arising over widespread stock deaths (Table 2). Overstocking of sheep pastures was thought to be responsible for poor stock condition that caused them to succumb to decease. These writers were referring to conditions in the eastern region of the Colony (Victoria East, Fort Beaufort and Albany), not the drier Karoo. Smith (1989) advocated rotational grazing (three camps), alternating sheep and cattle as cattle allow grass to grow longer, and judicious burning. Other writers (J.E.S 14th August 1890 p. 45) state that sheep deaths are due to the disease heartwater that can be linked to certain vegetation species. He notes that redwater in cattle is restricted by climate and is not found in the Karoo due to its dry climate. Hobson (1900) later noted that disease was beginning to appear in the Karoo midlands.

Ogilvie (1891) presents a history of sheep farming in the eastern districts of the Cape Colony where he had farmed since 1841 (Albany District and Fort Beaufort). Of relevance to the Karoo, he notes that during the second border war of 1850 between the British settlers and the Xhosa to the east a significant number of farmers trekked in to the Karoo for safety. Although many returned after the war, other farmers moved to Craddock and Graaff-Reinet when further war was rumored in 1856. Disease of livestock was also beginning to be a problem, which may have encouraged farmers to move to drier areas. Economic factors will also have affected stocking rates. In 1866-1870 there was a complete glut of land and stock, with low stock prices, but the opening up of diamond mines in Kimberley in the 1870s injected money into the economy and allowed farmers to reinvest. Land and sheep prices increased. Low stock prices have been cited as a factor contributing to higher stocking rates (Keay-Bright and Boardman, 2007). A combination of these factors may have lead to higher stocking rates in the Karoo after 1850. According to Dean and Macdonald (1994), some rangelands in the Karoo had already become stocked to capacity by 1865 and were showing signs of degradation (Dean et al., 1995). Availability of water restricted permanent settlement and stock numbers until the middle of the century, after which the practice of building farm dams became widespread. One of the earliest dams reported for the area was at Cranemere, built in 1843 (Palmer, 1993). A second factor that contributed to increased water security was the introduction of wind pumps from the early 1900s onwards to extract groundwater (Archer, 2000, Sittert, 2004)).

3.2 Veld condition and soil erosion

The first contributor to the AJCGH to link veld condition (vegetation cover) to erosion in the Karoo was Hobson in 1900 (Hobson, 1900). Several branches of the Hobson family still farm the plains to the South of the Sneeuberg escarpment so it is likely that Hobson also farmed in the same area. He was writing at a time when the Karoo had been subject to two years of severe drought, following two years of low rainfall. He acknowledged that drought and floods were the norm for the Karoo and that droughts were in fact important for maintaining vegetation health as, under natural conditions, they would provide a rest period. In the past springbok and other game kept the vegetation cover in a good state through a process of heavy grazing and manuring followed by rest.

Signs of degradation noted by Hobson (1900) included dead and decaying fodder plants being replaced by useless species and bare patches of soil appearing that “glisten and glare in the noonday sun” and “sloots that scar and farrow our fairest valleys during each thunderstorm, tearing up and carrying off their rich treasure of soil and vegetation only to bury them at some lower level beneath thousands of tons of desolate drifting sand.” (Hobson, 1900 p. 207). Hobson stressed the importance of the karoo bush *Pentzia incata* as the main component of the vegetation. He stated that this bush thrives on heavy grazing but constant stocking prevents reproduction. Rest from grazing is needed to allow seeding and for young plants to become established by “layering”, the production of adventitious roots from spreading branches that touch the soil. A second nutritious species, spekboom, also suffers the same problem, especially from Angora goats.

In addition to overgrazing without a rest period, Hobson (1900) blamed kraaling and the introduction of the American axe that encouraged bigger trees to be felled. Burning was also a problem. He advocated fencing to control grazing patterns. Kraaling was a common practice for protecting sheep at night against the predatory jackals. He observed that tracks created to and from the kraals furrowed water, leaving the karoo bushes on isolated hummocks, leading to eventual death of the plants.

Other contributors noted that siltation of farm dams had been a problem since the 1870s. McNaughton (1898) described how he had built a dam (near Graaff-Reinet) in 1870 that had filled up in four years. Clearly soil erosion was an active process, but there is no way of knowing from these writings whether this was the natural dryland process, or a sign of soil degradation.

3.3 The timing of gully erosion

ER Bradfield of Queenstown initiated the main debate around soil erosion in a paper in the journal entitled ‘The preservation of the soil from damage caused by sluits’ (Bradfield, 1903a). Other writers who took up the clarion call to tackle the problem of gully erosion were Gordon (1904), Sim (1904), Dugmore (1905), Braine (1906) Kanthak (1908) and Bradfield again in 1908 (Table 2). Gordon, Sim and Dugmore all talked about ‘the evil of sluits’.

It is clear from the various articles in the AJCGH that by the turn of the nineteenth century the erosion of valley floors by deep gullies was a widespread phenomenon of serious proportions. Writers provide some evidence to indicate when the problem may have started. Bradfield (1903a) refers to an engineer who a “few years” previously had issued a warning that, if measures were not put in place to curtail erosion, great damage would result. No date is given. The inference from Bradfield’s comments is that widespread gullying was a fairly recent process, but had accelerated rapidly by 1903. “How changed in the space of a short few years.” (Bradfield, 1903 pp. 192). Along with other contributors Bradfield notes deep gullies on what were recently unbroken grassy valley bottoms (Bradfield, 1903a; Dugmore, 1905; Anon, 1905; Braine, 1906). Dugmore (1905) believed gullies to be in their early stages of formation, with continued rapid expansion. A farmer, Mr. Southey, (Anon 1905) reported that during a tour of the Karoo in the early 1870s he had come across men in their eighties who remembered valley floors that in their youth had been marshy ground but were now dissected by deep dongas. This suggests that erosion did not begin in this instance until after 1820. Braine (1906) describes gullies that had formed within the last twenty years. According to Braine (1906), the Brak River near Britstown, that 50 years ago (1850s) was a "marshy depression full of long grass and bushes, now runs through a donga 200 feet wide and some 18 feet deep" (Braine, 1906 p.812). Kanthak (1930) reiterates this theme, describing the former vleis of the Brak River that existed in the 1860s. The river consisted of isolated pools running through flat, deep alluvium that extended in places for three to five kilometers away from the main drainage line. The vegetation was described as ‘sweet grass’. By 1907, when Kanthak visited the area, the Brak River was 100 m wide and 7 m deep while the flats were a wilderness scoured by ravines.

3.4 Causes of erosion and remedial measures

Table 3. Cause, effects and remedial measures as proposed by Gordon (1904)

causes	effects	measures
destruction of forests, trees & shrubs; grass burning	rapid runoff, increased flooding; increased soil erosion; siltation of irrigation and stock dams	small dams across headwater channels, roads, cattle tracks; earth embankments across slopes; tree & shrub planting; prevention of grass burning
overstocking; sheep and cattle tracks - kraals; herding of sheep and cattle	lowering of groundwater table; diminished spring flow, reduction of brak (salt) due to increased subsoil drainage (a positive effect) reduction of areas of cultivation	increased number of watering places formation of paddocks with cattle tracks aligned along the contour weirs and furrows to divert flood water onto land
roads and railways	change in vegetation composition and reduced drought resistance possible decrease in rainfall	facilitate cooperation between all concerned; consider how government can assist

Causes of erosion proposed by these authors included roads located through alluvial valleys (Bradfield, 1903; Gordon, 1904), railway culverts (Gordon, 1904; Dugmore, 1905), clearing trees, bushes and shrubs and grass burning (Sim, 1904; Gordon, 1904; Braine, 1906), heavy stocking and cattle tracks leading to and from kraals or watering points (Hobson, 1900; Gordon, 1904; Sim, 1904). Gordon (1904) suggested that increased runoff from hillslopes was the main cause of valley floor erosion whereas Dugmore (1905) proposed that, in the higher rainfall areas around Indwe and Lady Frere to the east, spring burning of grass on the valley floors followed by heavy grazing by ewes and lambs was causing loss of protective vegetation, promoting gully erosion by intense summer storms in January to March. Dugmore had observed 3 m deep gullies with abrupt headcuts that retreated up valley until a rock outcrop was reached.

Various solutions to the erosion problem were proposed. These included fencing to control stock movements and rotational grazing, prevention of burning, planting of vegetation (trees), construction of contour banks on slopes and check dams across gullies, roads and cattle tracks, diversion of floodwater onto the land or into storage dams using weirs and furrows. Table 3 summarizes the causes, effects and remedial measures proposed by Gordon (1904).

4. Contemporary rainfall

Gullies are a response to the erosive force of flowing water, so their formation is linked to the occurrence of overland flow. One might expect, therefore, that active gully erosion would be contemporaneous with periods of heavy rainfall. Boardman et al. (2003) and Keay-Bright and Boardman (2007) have observed that a fall of 10 mm can be sufficient to initiate overland flow, but higher amounts are required for that flow to connect with the wider drainage network. Daily rainfall records are available from 1874 and 1891 for two Karoo farms, Wellwood and Cranemere respectively (see Figure 1 for their location). These records have been analyzed with the objective or revealing potentially erosive periods when gully erosion would be active.

The two farms are 70 km apart in different topographic settings. Wellwood is situated in a topographic basin at an altitude of 1208 m whereas Cranemere lies below the escarpment on the edge of the Cambedoo plains at 755 m. Despite these differences the pattern of their annual rainfall is remarkably similar (Figure 2 a), suggesting that these records are also indicative of wider regional trends. In only two years, 1888 and 1890, did the trend differ for the two stations. Figures 2b and 2c show the distribution of storms recorded at the two stations that exceeded 20 mm. It can be seen that both recorded high rainfall in September 1891 (90 mm at Wellwood on 16 Sep, 81mm at Cranemere on the 15-16 Sep), an event that lay within a period characterized by frequent heavy falls. Wellwood recorded 8 daily falls >30mm between August 1900 and April 1902, 5 of these exceeded 50 mm. Cranemere had 6 falls > 30 mm over the same period. This period of high intensity rainfall occurred shortly before Bradfield (1903), and others after him, raised concern about gully erosion. It is therefore feasible that heavy rains in this period activated gullies that may already have started to form, to an extent that caused alarm among local farmers and government officials.

According to reports in the AJCGH, good rains in January 1900 broke a regional drought that had persisted for over two years. Dams had been dry since October 1897, fountains (springs) were running dry and animals were relying on artificial fodder. Nonetheless, both Cranemere and Wellwood recorded several heavy falls during this period. One can therefore surmise that between 1887 and 1899 isolated falls of intense rainfall during a period of regional drought caused local erosion in a poorly vegetated landscape. An increased drainage density on hillslopes and local valley floor erosion could have primed the system for widespread valley floor incision during the following wet period.

5. Discussion

5.1 Erosion in the Karoo

There is clear evidence of active gully erosion persisting on valley floors of the Karoo in the late nineteenth and early twentieth century. There is also evidence to support the claim that incision of valley floor wetlands was initiated after the 1820s, and even the 1860s, but was present by the 1870s. There were a number of reports that suggested that at the turn of the century valley floor incision was perceived to be a recent phenomenon. The rainfall record provides some evidence to support the claim that intense rainfall between August 1990 and April 1992 activated (or reactivated) valley floor erosion in an area that had recently suffered a long period of drought, raising alarm among officials and farmers.

Graf (1979), working in the USA, found vegetation cover in both the catchment and the valley floor to be an important determinant of channel incision through gully erosion, and it is likely that loss of vegetation cover, whether through heavy grazing, drought or a combination of both, contributed to erosion in Karoo valley floors. Cooke and Reeves (1976) emphasized the role of structural changes (roads, canals, ditches, embankments) that would effectively concentrate water flow and increase the hydraulic power of the water. Neville (1996) blamed the roads along which livestock were driven in their thousands as a major cause of gully initiation in the Sneeuberg Mountains. A number of authors, however, have cautioned against claiming that gully erosion can be attributed only to anthropogenic causes, citing other factors such as periods of high intensity rainfall, and intrinsic changes that promote natural cycles of cut and fill in a semi arid climate (cf. Patton and Schumm 1975, 1981; Cooke and Reeves, 1976; Turner et al., 2003).

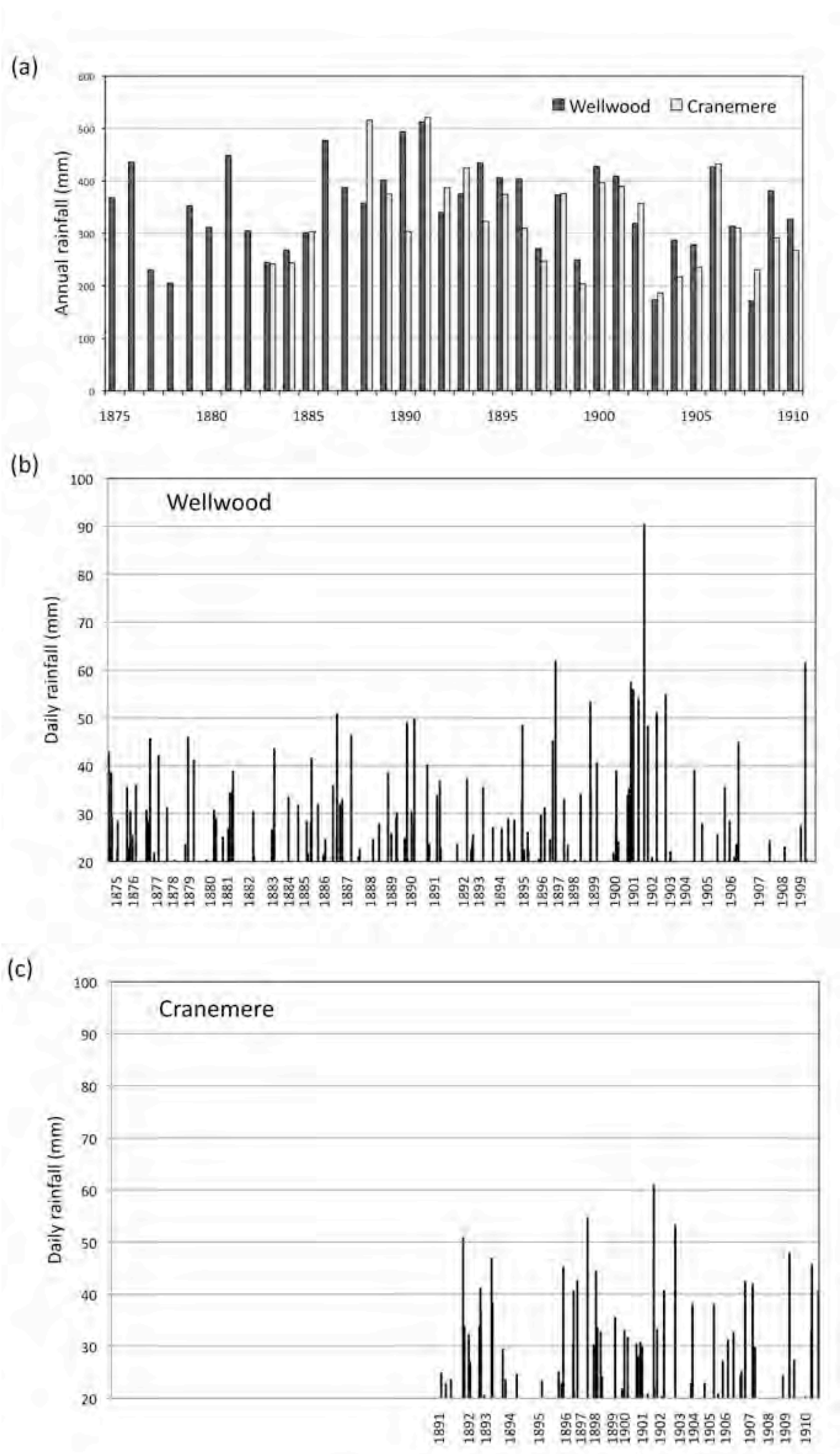

Fig. 2. Rainfall at Cranemere and Wellwood, 1875-1910. (a) comparison of annual rainfall (b) time series of daily rainfall events exceeding 20 mm at Wellwood (c) time series of daily rainfall events exceeding 20 mm at Cranemere.

Turner et al. (2003) reevaluated the ecology of vegetation change in the American Southwest. They describe how marshy valley floors characterized by slow flowing meandering streams with pools supporting fish and beaver populations in the mid nineteenth century had been transformed by deep gullies by the end of the century. They ascribe ecological change to a complex set of factors. Severe flooding in the late 1880s is believed to have triggered widespread extension of incised channels within a landscape that had suffered heavy grazing since the end of the American Civil War. Their descriptions of change closely mirror those of Karoo observers.

In the case of nineteenth century erosion in the Karoo, there is strong evidence that extensive valley floor incision can be related to the impact of livestock farmers of European origin and, in particular, to the permanent settlement of farms that began to take place after the middle of the nineteenth century. This provides support for the assertions made by the several authors cited in Section 2 who ascribed initial degradation to this period. There is no reason to believe that this incision was not the result of the livestock economy, whether through increased runoff due to reduced vegetation on hillslopes, channelling of runoff along roads and footpaths, or reduced vegetation cover on the valley floor. Such changes would bring the valley floors closer to a threshold where enhanced runoff during heavy rains could initiate channel incision as postulated by Patton and Schumm (1975) for gullies in Colorado.

Brooks and Brierley (1997), Brierley and Murn (1997) and Brierley and Fryers (1999) describe the transformation of natural discontinuous gully networks into integrated incised channels in the Bega Valley, New South Wales, Australia, between 1890 and 1900. They ascribed the cause to cultivation of the valley floor flats, road building and extreme floods. Barrow (1806) also described a discontinuous channel for the Seekoe River, and discontinuous gullies may well have been a natural feature of the Karoo. Kanthak (1930) described similar features for the Brak River. The process described for Australia therefore parallels closely that described here for the Karoo.

5.2 Evaluating the data source

This paper has presented evidence for the initiation of channel incision based on articles in the AJGHC between 1889 and 1910. Here the credibility of these writings is appraised. These articles were not peer reviewed in the modern sense. It would have been the sole prerogative of the editor whether or not an article or letter was published. There was, however, an active peer review process in the form of the debates raised by the contributions to the journal. The articles are true reflections of the concerns of the farmers and of their recommendations to solve problems. All articles were written in English and therefore exclude contributions from Afrikaans farmers of Dutch origin, the first Europeans to practice livestock farming in the Karoo. Contributors were articulate, undoubtedly well educated and often worldly. One writer describes at length farming practices observed while visiting Texas in the USA (Anon, 1900).

Authors were in most cases named, but their occupation (farmer or official) was not always clear. Government officials were more likely to be identified by their position; Gordon’s designation was given as Irrigation Officer and Sim as District Forest Officer. Neither was the location of the writing always evident. All authors came from the Cape of Good Hope, but may not always have been writing about the Karoo. Erosion was also a pervasive problem in the wetter area to the east (e.g. Dugmore, 1905). Vague descriptions were often given to locations and time of events (eg. “a few years ago”).

The descriptions of erosion given in the AJCGH are based on astute field observation by people living and working on the land, rather than on scientific experiment or rigorous data collection. They therefore constitute a form of local knowledge. Land degradation scientists have called for local knowledge to be incorporated into land degradation assessment and land management policy development (cf Lykke et al., 1999, Stringer and Reid, 2007, Chasek et al., 2011, Reed et al., 2011, Yiran et al., 2012). Hoffman and Todd (2000) used workshops with agricultural extension officers as the basis of a national survey of land degradation in South Africa. In most cases local knowledge is equated to indigenous knowledge, the accumulated knowledge of a community that has lived in the area for several generations. In the case of the Karoo farmers writing in the AJCGH, all contributors were English speaking and their families would have only settled in the area from the mid nineteenth century onwards. At best they would have been second-generation farmers, many may have been first generation. Their own indigenous knowledge was of the British Isles, a very different environment. They could have over reacted to what is a natural process in semi-arid landscapes. Government officials may have arrived in the area even more recently, but would also have had a wider experience of the Cape Colony.

Farmers had to adapt quickly to their new environment if they were to survive, but often their recommended solutions arose from their indigenous knowledge of Britain. A good example of this is the desire to create plantations of exotic trees, many of which are now considered to be invasive alien species. For example, Sim, the District Forest Officer for King Williams Town to the east wrote on ‘The evil of sluits and how far it could be prevented and remedied by tree-planting’ (Sim 1904).

Creditable local knowledge about geomorphic processes is exemplified by Sim (1904) and Dugmore (1905). Sim (1904) advocated that attention be focused on small gullies feeding the main gully as the latter was normally too active to respond to remedial actions. Dugmore (1905) suggested that vertical banks should be allowed to slump, leading to sloping banks that would become grassed over. Stone slopes could be used to stabilize headcuts. He also recommended fencing of eroded area and stock exclusion. These proposed measures were endorsed eighty years later by the geomorphologists Schumm et al. (1984), but it is not easy to assess the effectiveness of these measures in addressing the soil erosion problem in the study area. This would require in-depth local scale research outside the bounds of the present paper.

More contentious than the erosion measures were the proposals for tree or grass planting. Recommended species were often from Europe or Australia (van Sittert, 2000) and represented a disturbance to the natural Karoo ecosystem. Although there was concern over the spread of noxious weeds of foreign origin (van Sittert, 2000), there was no restraint shown in recommending alien species for rehabilitation purposes. With heightened awareness of the negative impacts of alien species, which often become invasive, South Africa has recently promoted vegetation clearance programmes through the Department of Water Affairs Working for Water Programme that has been actively clearing invasive alien vegetation from catchments and watercourses since the 1995 (Department of Water Affairs, no date). Species alien to South Africa have been classified according to their invasive category. Table 4 gives a list of tree and grass species proposed as a remedy for erosion in the Karoo, classified according to their invasive category as decreed under the Conservation of Agricultural Resources Act of 1983 (Agricultural Research Council, 2011). This is therefore an example where the enthusiastic promotion of an idea arising from foreign notions of what is best for the environment can have serious negative consequences.

Table 4: Alien invasive category of plants recommended for erosion control in the Karoo

Species	Common name	Alien invasive category
Cortoderia selloana; C. jubarta	pampas grass	1 (complete ban)
Acacia dealbata	silver wattle	2 (can only be planted with permission)
Eucalyptus spp.	eucalypt	
Populus alba; P. canescens	white poplar; grey polar	
Pinus pinaster; P. patula	cluster pine; patula pine	
Robinia pseudoacacia	black locust/false acacia	
Salix balylonica; S. fragilis	weeping willow; crack willow	
Ligstrum spp.	privet	3 (can remain if already planted but not within 50 m of the 1:50 yr flood line)

5. Conclusions

A series of articles published in the Agricultural Journal of the Cape of Good Hope has been used to determine more precisely the timing of valley floor incision and gully expansion in the eastern Karoo of South Africa. It is evident that gully erosion was active in the first decade of the twentieth century and that many cases of incision had happened within the last twenty years, causing the desiccation of previous wetlands. Writers attributed the erosion to heavy stocking, kraaling and poor land management, with associated loss of vegetation cover and channeling of water along footpaths and roads. Drought and periods of intense rainfall would also have exacerbated the erosion hazard. Keay-Bright and Boardman's (2006, 2007, 2009) survey of the extent of gully erosion in the Sneeuberg has shown that the gully network had stabilized by 1945, while recent work on sediment accumulation in farm dams has indicated that rates were relatively low until the 1960s (Foster et al., 2012). It can therefore be concluded that, although dramatic features, the gullies stabilized within 100 years of their initial formation and were never a major source of downstream sediment. Hillslope erosion, especially through the development of badlands, has probably always been the main sediment source, the valley floor gullies acting as efficient pathways for sediment movement.

The authenticity of the writings in the AJCGH was assessed within the context of local knowledge. There was no peer review process prior to publication, but ongoing debate around selected issues, the 'evil of sluits' being one example, enabled a form of peer review. Some writers also had insight into the global context, such as the report on the situation in Texas (Anon, 1900). The authors clearly had a good local knowledge of their environment, but it can not be deemed indigenous knowledge due to the short time since settlement by European farmers took place, especially the English speaking farmers writing in the journal. Their indigenous knowledge was based on their European experience, the wetter and more predictable climate contrasting strongly with the highly variable climate of the Cape Colony and the dynamic ecological response of the Karoo vegetation.

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