Dorback Burn, Highland

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Highlights

Dorback Burn, a tributary of the River Nethy in the Cairngorm Mountains, provides an excellent example of an active wandering gravel-bed river, a channel type which is common throughout much of upland Scotland. Its behaviour has been systematically monitored since 1978, thus providing a unique study of channel pattern change in the headwaters of a small upland drainage basin.

Introduction

This site is representative of many headwater reaches of gravel-bed rivers in upland Scotland.

Since 1948 it has displayed both a braided and a meandering planform according to the magnitude and timing of formative floods (Werritty, 1984). Flash floods resulting from localized convective storms generate large-scale channel change, typically involving avulsion rather than progressive lateral migration of the main channels. By contrast, smaller competent events restore a highly divided channel to a simpler, more integrated channel within which a meandering planform locally emerges. In magnitude-frequency terms, this channel's behaviour is thus more akin to the high-threshold, bedload channels investigated in Texas by Baker (1977) than the low-threshold, fine-grained channels of the eastern USA reported by Wolman and Miller (1960). The high threshold for channel change arises from the grain size of the bed material (D_{84} of 50–70 mm) and the size of the critical shear stress necessary to mobilize the sediments. Long-duration, low rainfall intensity frontal storms are unlikely to generate the required shear stress, whereas short, intense convective storms have repeatedly proved effective in generating large-scale bedload transport.

Description

Dorback Burn is a north-west-flowing tributary of the River Nethy which drains the northern part of the Cairngorm Mountains and flows into the River Spey at Nethybridge. The study reach is a 250 m length of channel located where the drainage area of Dorback Burn is only 18.6 km^2 (Werritty, 1984). Throughout most of its course this stream presents a meandering undivided channel. However, at this site the channel is better described as a 'wandering gravel-bed river', since it has a high width : depth ratio and is braided, with typically two or three channels present in any one cross-section (Figure 2.33). Each channel is 3–6 m wide, has a slope of *c.* 0.01 and under normal flow conditions is up to 30 cm deep. The bed generally comprises medium-sized cobbles (with a D_M of 50–70 mm), but there is also extensive finer-grained material on the flood-plain and sandy infill in abandoned channels. A weak pool–riffle sequence is present, with the pools located in the major bends. The position of the riffles is controlled by the location of the major mid-channel bars. Since these bars are erratic in their location, the channel does not readily conform to the alternate bar pattern which is common in many of the larger gravel-bed rivers of Scotland.

Interpretation

The study reach is noteworthy for four reasons. Firstly, it is remarkable in terms of the rapidity and extent of channel pattern change over the past 40 years. This has been monitored using repeated aerial photography plus regular topographical survey of the reach (levelling of cross-sections and large-scale planimetric mapping). During this period the *c.* 50 m wide active area (roughly ten channel widths) has been repeatedly reworked both by avulsion during large floods and by lateral migration during the intervening periods.

Secondly, this site is noteworthy on account of the fact that the channel can exhibit various degrees of both braiding and meandering at different times. This confirms the assertion that channel pattern is a continuum rather than a set of discrete states (Ferguson, 1987). The study reach is usually characterized by the braided channel pattern described above. However, analysis of the longer-term development of the reach has demonstrated that this pattern is an unstable one (Werritty, 1984). Thus a cyclic pattern has been recorded in which the degree of channel subdivision is determined by the impact of major overbank floods. Immediately after such a flood, the extent and degree of channel subdivision is markedly increased, such that momentarily the channel can locally resemble a scaled-down proglacial sandur (Figure 2.34). However, this type of channel configuration is unstable, and the highly divided channel soon reverts to a much simpler channel pattern with only two or three multiple channels present. If there are prolonged periods without major overbank floods, the braided pattern can even temporarily revert to an undivided meandering channel (cf. the much larger River Feshie; Werritty and Ferguson, 1980).

Thirdly, the site is significant because it has been evaluated in terms of the formative processes currently operating on such gravel-bed streams. The calibre of the bed material ensures that bedload transport is highly episodic and short-lived in duration, such transport occurring in response to intense summer convective storms. Thus, in magnitude-frequency terms, the site registers a high threshold for sediment entrainment coupled with a right-skewed distribution of formative discharges (cf. Baker, 1977). Both factors tend to emphasize the role of major floods in controlling the channel configuration and the pattern and rate of floodplain reworking. Two major floods have been analysed in terms of their geomorphic impact on the channel configuration (Figure 2.34). The first occurred on 4 July 1978 when an estimated peak discharge of 26 m^3s^{-1} was recorded at the study reach. Dramatic channel pattern change was reported as a result of this flood. However, this flow was substantially exceeded by a flood on 6 June 1980 which paradoxically registered a much more modest impact in terms of active area reworking. An unknown discharge also occurred on 20–21 September 1981, again with only a modest impact in terms of channel pattern change. Between September 1981 and 1994 there have been no significant overbank floods, and the channel configuration has changed only very slightly during this period. It is noteworthy that the two formative events within the period 1978–94 were closely spaced and have not been repeated. The channel configuration created by the 1981 storm was still identifiable in 1994, only minor modification to individual bars and bends being registered. The development of the channel system at this site is one of large-scale change during formative floods, punctuated by periods of stability. This confirms the need for long-term monitoring of such sites, if valid geomorphic inferences are to be drawn (Church, 1984).

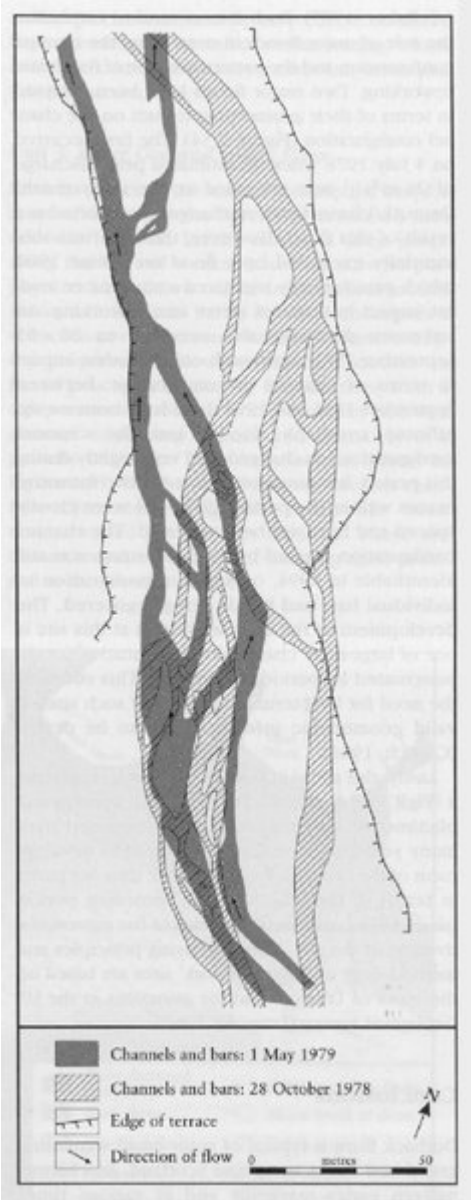
Lastly, this site is important because it represents a 'Vigil' site at which cross-sectional surveys and planimetric mapping have been repeated over many years to document the long-term development of the channel. Its significance thus lies partly in terms of the length of the recording period (since 1978), and partly in terms of the representativeness of the site. The underlying principles and methodology of 'Vigil Network' sites are based on the work of Leopold and his associates in the US Geological Survey (Leopold, 1962).

Conclusions

Dorback Burn is typical of many small wandering gravel-bed rivers in upland Scotland. Its channel pattern varies markedly and at various times embraces degrees of both meandering and braided planform development, thus confirming the assertion that channel planform comprises a continuum. The specific channel configuration at any given time is determined by the occurrence of floods capable of generating significant bedload transport rates. These are both infrequent and erratic, and thus the channel can be stable for many years between formative floods. In magnitude frequency terms, channel change and associated reworking of the floodplain are determined by floods which are relatively rare (two in 16 years) but may be closely spaced.

References

(Figure 2.33) Dorback Burn: a small wandering gravel-bed river in which an actively braided channel is reworking the valley floor. (Photo: Royal Commission on the Ancient and Historical Monuments of Scotland; F 22543/RAF/1428; flown August 1961: Crown Copyright.)



(Figure 2.34) Dorback Burn: the highly divided sandur-like channel in October 1978 following the flood of 4 July 1978, contrasted with the simpler channel pattern in May, 1979. (After Werritty, 1984.)