Highland Water, Hampshire

[SU 272 073]–[SU 239 912]

Highlights

The Highland Water provides an excellent example of the influence of vegetation on river-channel processes in the heathland and forestry context of the New Forest, Hampshire. The presence of coarse woody debris in the river channel is of particular importance in relation to the channel morphology, hydrology and ecology of the catchment, while types of heathland influence the character and amount of runoff.

Introduction

The site has been investigated to establish how the influence of vegetation relates to the processes operating in river channels. This is important for understanding the routing of flood peaks through a fluvial system and the modelling of channel processes at different stages of flow; for understanding patterns of channel and floodplain sedimentation; for the enhanced interpretation of palaeohydrological evidence; and in relation to effective channel management (Gregory, 1992; Gregory and Davis, 1992).

Description

Coarse woody debris: Highland Water

In river channels bordered by trees or flowing through woodland, the presence of organic material in the channels is important in affecting fluvial processes. In these areas trees and branches may fall into the river system through storm events, bank erosion or tree fatality. This coarse woody debris may be redistributed by the river into discrete accumulations known as debris dams; leaf litter may also be stored in these accumulations (Figure 6.16).

The Highland Water drainage area is 11.4 km^2 above the two gauging stations just below Millyford Bridge. A number of studies have focused on the role of organic debris in the river. A classification of debris accumulations was undertaken along the main channel by Gregory *et* al. (1985). Three types of debris dams were recognized: active dams (Figure 6.16) form a complete barrier to water and sediment movement and create a distinct step or fall in the channel profile; complete dams provide a complete barrier across the channel but do not create a definite step in the channel profile; and partial dams are not completely developed across the width of the channel. The debris dams occurred on average once every 27 m of channel, and when resurveyed after one year 36% had changed position or were destroyed, and 36% had changed character. Partial dams were the most numerous (46.3%), and active and complete dams were less frequent (32.2% and 21.5% respectively). Active dams were much more common in two headwater streams (66.7%) and decreased downstream.

The river has subsequently been re-surveyed to establish change in the temporal and spatial distribution of the debris dams (Gregory, 1992; Gregory *et al.,* 1993). The importance of high return period storm events in relation to the input of large organic debris was demonstrated by Gregory (1992). The severe storm events of 1987 and 1990 caused a high degree of blowdown and injected large amounts of debris into the system. A survey of the whole of the Lymington basin (110 km^2), which includes the Highland Water, reported debris dam densities of 1.15 per 100 m of channel (Gregory *et al.,* 1993).

Coarse woody debris: Millyford Bridge

The influence of coarse woody debris at the reach scale has also been investigated at a reach between Millyford Bridge and two gauging stations further downstream. Within the 78 m length reach, changes in the distribution of debris and in channel cross-sections have been recorded (Figure 6.17) to indicate the dynamic nature of channel change in relation to debris distribution. An intensive yearlong study (1990–91) in the reach documented an increase of debris loading in response to the formation of a debris dam in the lower reach. This was equivalent to an increase in debris loading along the reach from 1.42 kgm^{-2} in October 1990 to 3.85 kgm^{-2} in November 1991. The conditions created by this dam have redirected the flow involving the development of a subsurface cavity after the washout of gravels, which is succeeded by slow subsidence (Davis and Gregory, 1994).

This type of bank erosion may occur elsewhere in channels in temperate woodlands.

Witbybed subcatchment

The Withybed subcatchment encloses the eastern part of the heathland zone of the Highland Water catchment. It has been surveyed in detail (Figure 6.18) to establish the interrelation of vegetation and groundwater (Gurnell and Gregory, 1984; Gurnell *et al.,* 1985). In contrast to the rest of the catchment, the area contains areas of high soil moisture content. Transects were selected to reflect the range of heath categories in the soil moisture vegetation map produced according to soil moisture variations.

The position of areas of high soil moisture content, such as the moist heath category, in relation to the main drainage network is an important factor determining runoff production. These areas are often quite remote from the main drainage network and so may produce a complex response to different temporal and spatial patterns of rainfall. Such a relationship is of considerable significance for linking the character of the vegetation composition to the catchment runoff response.

Seepage steps

The heathland areas of the catchment are pod-solized, and leaching has greatly reduced the cohesion of the sandy matrix of the gravel and so decreased its resistance to erosion once the vegetation cover is removed. Gullies have developed mainly in the gravel or other soliflucted material. The example incorporated in the site limits is on the south-west slope of Stoney Cross Plain, at [SU 252 107]. More than one incipient gully typically forms on the same slope, where the local increase in gradient is greater than the general increase for that slope. In these cases, the separate gullies grow by deepening and headward erosion until they coalesce, and the junction between the two sections is marked by a prominent seepage step, often 0.75–1.00 m in height (Figure 6.19). These tend to persist, migrating slowly upslope.

The headward extension of a gully by headstep migration seems to be a very slow process, although headward growth can be achieved much more rapidly by the development of small incipient gullies immediately above the main one. The rapid longitudinal growth of gullies on hillslopes, up to 65 m in two years in this case (Tuckfield, 1964), is achieved by the coalescence of discontinuous sections rather than by headward erosion by upward step migration.

Interpretation

Stream channel morphology is influenced by the discharge, particularly the peak flows moving down the channel; the sediment that is transported; and the local channel-forming characteristics, including the vegetation. In lowland British stream channels the riparian vegetation is a significant influence determining the stream channel morphology. This is very well demonstrated along the course of the Highland Water. The stream channel processes are influenced by the material from blowdown and leaf litter fall that each year contribute to organic accumulations in the stream channel.

Debris dams are particularly significant in relation to the distribution of stream channel processes, and particularly in relation to the distribution of flooding. It was originally thought that flooding might take place extensively across the floodplain of a small stream or river, but it is now appreciated that the debris dams can lead to localization of flooding because one major dam causes flooding upstream, whereas immediately downstream of the dam the flood discharge is contained within the river channel.

A number of major implications have been demonstrated from extended study of the Highland Water. The reduction in velocity and discharge arising because of the pools held upstream of the dams, the retardation of bedload movement and the effect upon the pool–riffle sequence, the localization of bank erosion along the channel, and the localized overbank sedimentation which occurs because of floodplain inundation upstream of dams, are among the most obvious effects. The dams also influence the way in which energy of the stream is used, according to which of the three types a particular dam belongs.

Adjustments of the channel have been effected by three groups of influences. Firstly, road drainage has been fed into the channel immediately below the point at which the A31 (converted to dual carriageway in 1980) crosses the stream. More significantly, there is a stretch of the stream that was channelized by the Forestry Commission in 1966, leading to several cutoffs being produced, increasing the slope of the channel which may have in-channel erosion downstream. In addition, drainage along tracks may have increased in recent years, and the position of debris dams has influenced the precise location of erosion.

A survey of the inter-riffle spacing along 6 km of the main channel (Gregory *et al.,* 1994) has shown that the spacing is generally within the range of 5–7 channel widths apart, which is in contrast to other studies of coarse woody debris, where a shorter spacing is generally found. This disparity could be due to the human impact of stream clearance preventing the establishment of debris dams and also to the inherent instability of the smaller pieces of coarse woody debris.

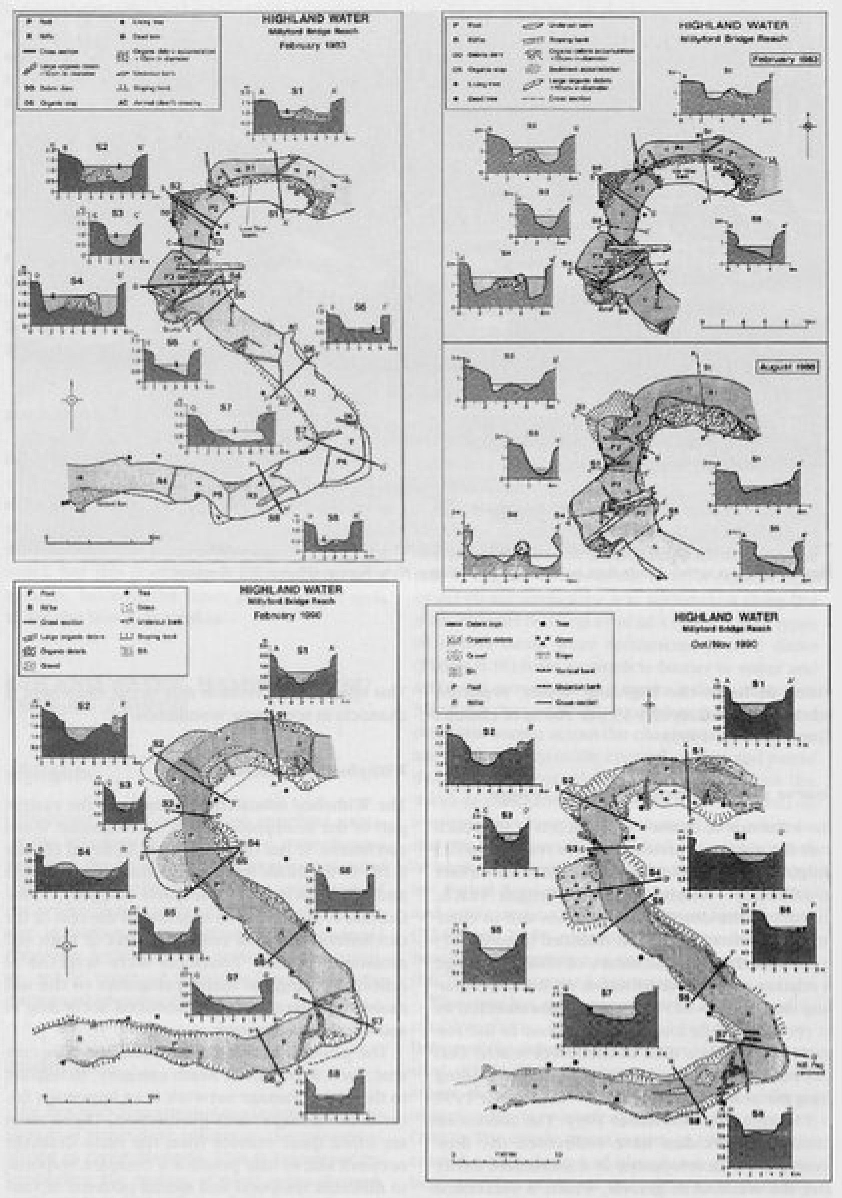
The Highland Water is significant because of the way in which it reflects the fluvial processes that are active in the relationship between stream channel processes in a woodland catchment. The accumulations of coarse woody debris are particularly important in the way in which they control sediment storage and transport, the formation of pools and riffles, and the processing of organic matter, as well as increasing the diversity of the river channel. In addition, certain parts of the stream channel are showing adjustment to changing processes through the existence of enlarging channel cross-sections, which can be identified by undercut banks, bent trees and exposed roots, when they occur on opposite sides of the channel. In these cases this indicates that the channel is enlarging rather than simply shifting its position autogenically (Gregory, 1992). On the reach scale, it has recently been shown that accumulations of coarse woody debris can initiate bank erosion, can introduce coarse sediment to the channel, and can initiate a form of bank erosion by creation of slow collapse of a cavity (Davis and Gregory, 1994). The importance of these natural accumulations of woody debris in woodland ecosystems cannot be overestimated. However, they are often threatened by human intervention and removal, often in the belief of aiding flood prevention in a forest system where floodplain inundation occurs naturally. The upper part of the Highland Water catchment has also been important for assessment of the effect of different types of vegetation on runoff generation. In addition, the area has some interesting seepage steps.

Conclusion

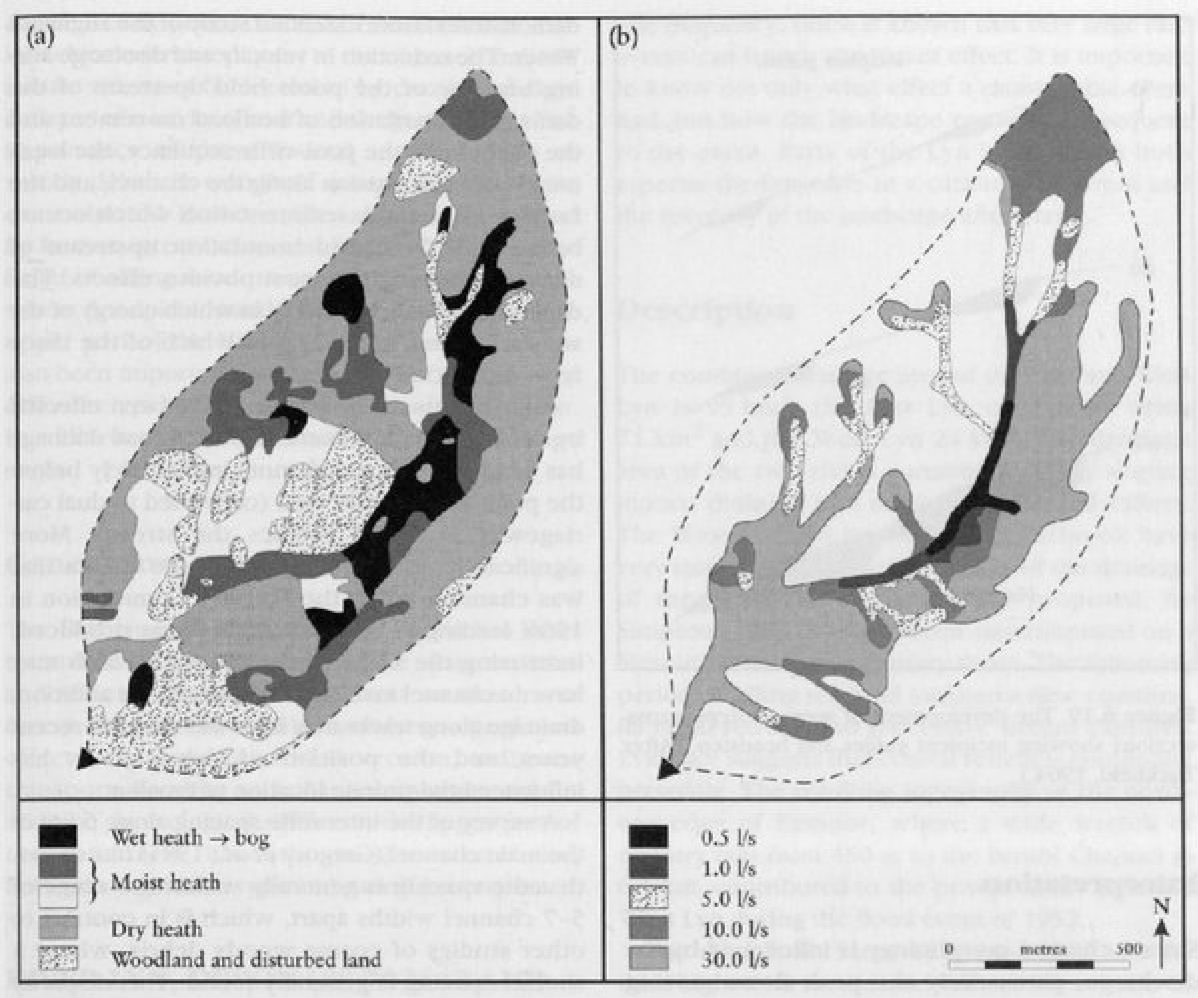
The Highland Water in the New Forest has been the subject of intensive study of the characteristics and effects of woody debris dams on streams in forested areas. The debris dams have a profound effect on processes of bank erosion, sediment transport, flooding and channel enlargement. In addition, hydrological studies in the upper part of the catchment have shown the interrelation between vegetation type and runoff generation.

References

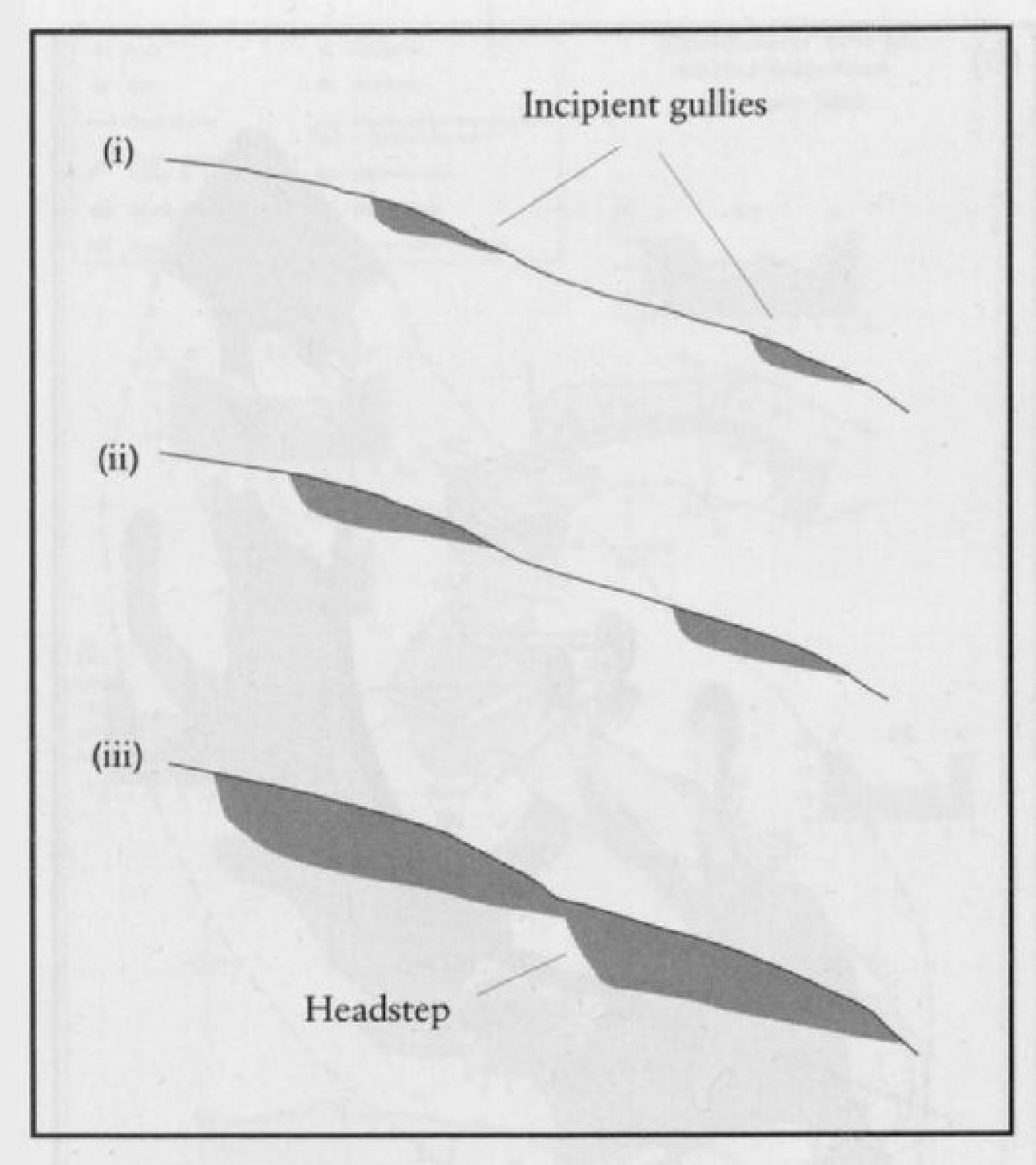
(Figure 6.16) An active debris dam on the Highland Water, New Forest. (Photo: K.J. Gregory.)



(Figure 6.17) Millyford Bridge reach, illustrating changes in debris location and channel morphology.



(Figure 6.18) The distribution of vegetation — soil moisture categories (a) and runoff contributing areas at different levels of baseflow (b) in the Withybed subcatchment. (After Gurnell et al., 1985.)



(Figure 6.19) The development of seepage steps: cross-sections showing incipient gullies and headstep. (After Tuckfield, 1964.)